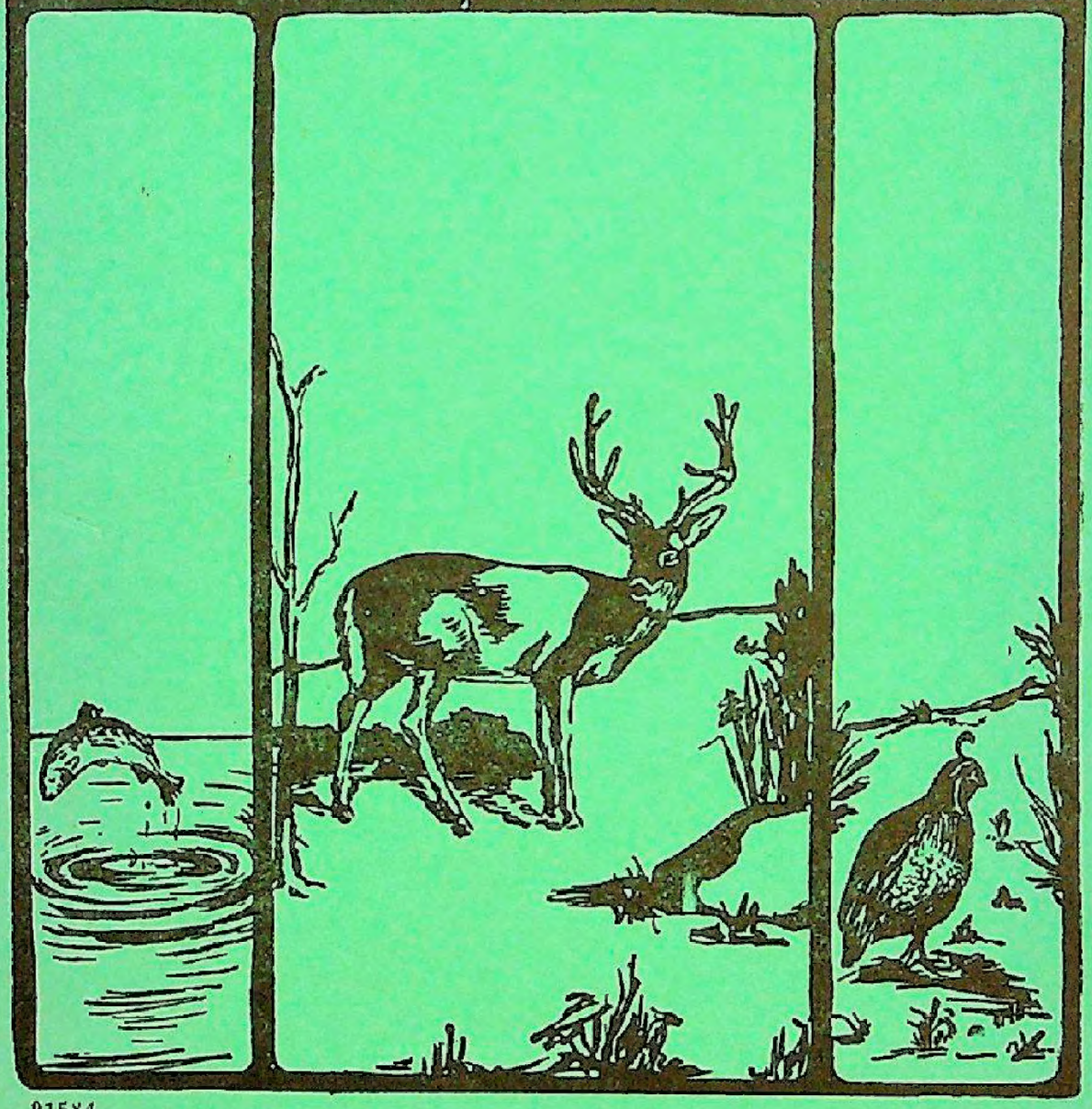
CALIFORNIA FISH AND GAME

"CONSERVATION OF WILD LIFE THROUGH EDUCATION"

Volume 26 San Francisco, October, 1940 Number 4



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DEPARTMENT OF NATURAL RESOURCES

DIVISION OF FISH AND GAME

San Francisco, California

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CALIFORNIA FISH AND GAME is a publication devoted to the conservation of wildlife. It is published quarterly by the California Division of Fish and Game. All material for publication should be sent to Richard S. Croker, editor, California Division of Fish and Game, Terminal Island, California.

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91584

PROGRESS REPORT ON GAME KILL STATISTICS[1]

By J. S. Hunter and Donald H. Fry, Jr.

California Division of Fish and Game

The game birds and animals of California form a very valuable natural resource which is administered by the Division of Fish and Game. In order to do its work, the Division should know how many of each species are taken in the various parts of the State. Such figures make it much easier to say with certainty that in one section the quail are doing splendidly, while in another they need added protection, or that in a certain region the annual pheasant kill is less than the number released by the game farms, while in an area better adapted to their requirements the kill is many times the number planted.

To start "keeping books" on any large natural resource is a herculean task, and getting game kill figures for the State is no exception to this rule. There are approximately a quarter of a million licensed hunters in California, and the Division wishes to know how much they kill throughout each part of the State. The man who can best estimate the kill of any given hunter is that hunter himself. Accordingly, the Division has attached questionnaires to hunting license application blanks every year since 1935, and in 1939 it mailed out an additional number of questionnaires to hunters who were licensed in 1938.

The data from these questionnaires have been analyzed, and part of the results are shown in the accompanying maps.

The methods used and difficulties encountered in obtaining a good estimate of the game kill are given in the latter part of this paper.

THE GAME BIRDS AND ANIMALS OF CALIFORNIA

Ducks and Geese

In 1938 the estimated duck kill was 950,000, and the goose kill was 90,000.

The species of waterfowl found in California make quite a formidable list. The more common forms are:

Geese

Canada Goose ..... *Branta canadensis canadensis*
White-cheeked Goose ..... *Branta canadensis occidentalis*
Lesser Canada Goose (formerly known as Hutchins' Goose) ..... *Branta canadensis leucopareia*
Cackling Goose ..... *Branta canadensis minima*
Black Brant ..... *Branta nigricans*
White-fronted Goose (Tule Goose) ..... *Anser albifrons gambeli*
Lesser Snow Goose ..... *Chen hyperboria hyperboria*
*Ross Goose ..... *Chen rossi*

---

[1] Submitted for publication, September, 1940. Most of the credit for this work should go to the staff members of the statistical department of the California State Fisheries Laboratory. Without their careful work on literally hundreds of thousands of questionnaires no game statistics would have been available.

* These species are fully protected.

Tree Ducks

Fulvous Tree Duck.....*Dendrocygna bicolor helva*

Surface-feeding Ducks (Fresh-water Ducks)

Mallard.....*Anas platyrhynchos platyrhynchos*
Gadwall.....*Chaulelasmus streperus*
Baldpate or American Widgeon.....*Mareca americana*
Pintail or Sprig.....*Dafila acuta tzitzihoa*
Green-winged Teal.....*Nettion carolinense*
Cinnamon Teal.....*Querquedula cyanoptera*
Shoveller or Spoonbill.....*Spatula clypeata*
*Wood Duck.....*Aix sponsa*

*These species are fully protected.

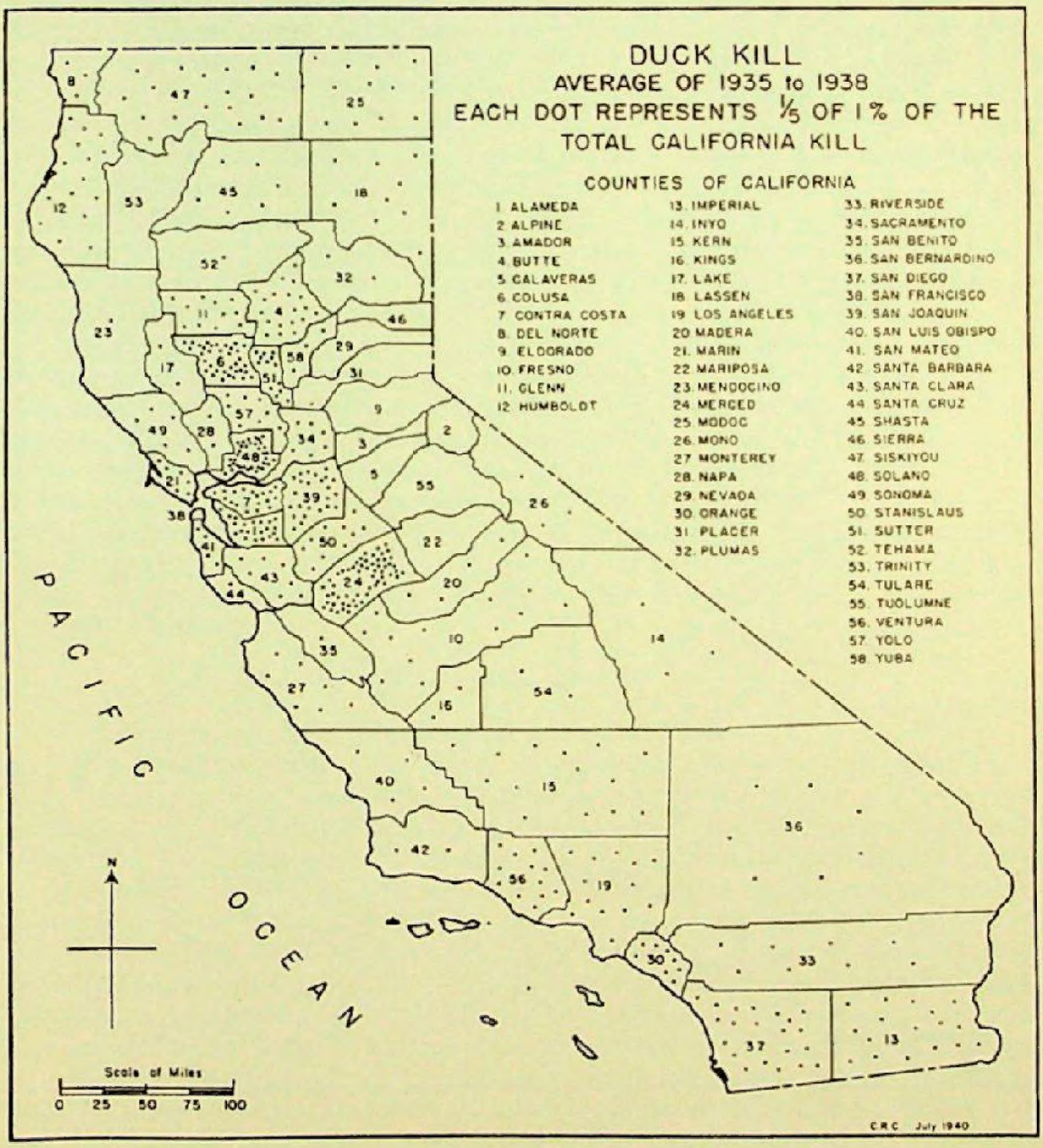

FIG. 111.

Diving Ducks

Redhead ..... *Nyroca americana*
Ring-necked Duck ..... *Nyroca collaris*
Canvas-back ..... *Nyroca valisineria*
Greater Scaup or Big Bluebill ..... *Nyroca marila*
Lesser Scaup or Little Bluebill ..... *Nyroca affinis*
American Golden-eye ..... *Glaucionetta clangula americana*
Buffle-head ..... *Charitonetta albeola*
White-winged Scoter ..... *Melanitta deglandi*
Surf Scoter ..... *Melanitta perspicillata*
Ruddy Duck ..... *Erismatura jamaicensis rubida*

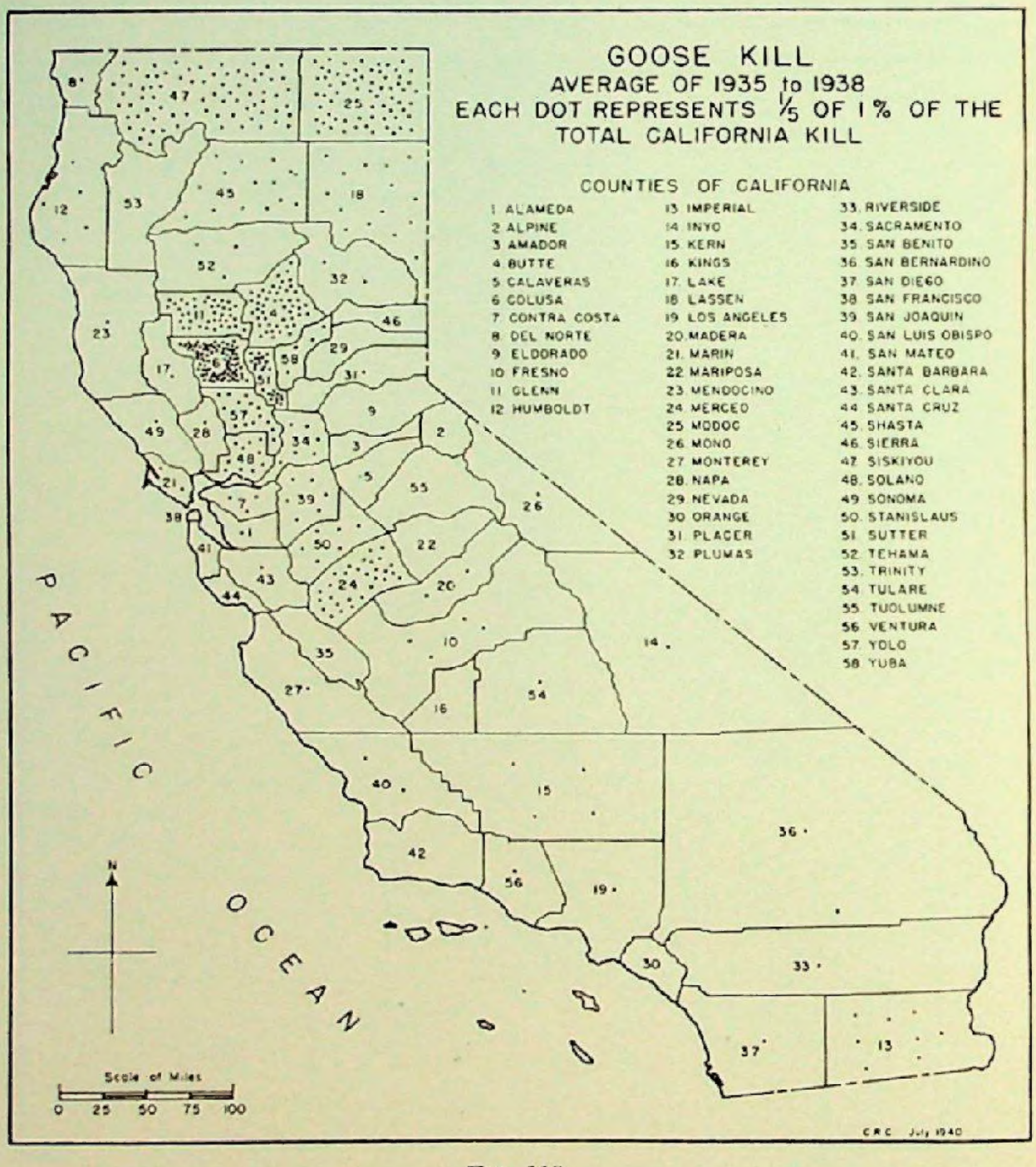

FIG. 112.

In general the fresh-water ducks and most of the geese are found in inland areas, such as northeastern California, the Sacramento-San Joaquin Valley and the Imperial Valley. However, there are some duck clubs and some natural fresh and brackish water areas near the coast where conditions are to the liking of surface-feeding ducks and where these birds congregate by the thousands.

The brant, the white-cheeked goose and the diving ducks are usually found in bays or lagoons along the coast. Some diving ducks—the scoters—are often found in the open ocean. This coastwise distribution is not hard and fast—the diving ducks do visit inland lakes, but they prefer larger and deeper bodies of water.

In general the best fresh-water or puddle duck and goose grounds are occupied by duck clubs and waterfowl refuges, and the unattached hunter has little opportunity to enjoy good hunting. This is especially true of southern California, much less so of the extreme northern part of the State.

There is quite a bit of salt-water hunting, primarily for bluebills, canvas-backs, ruddies and brant. Brant are only found in two or three localities and are hard to get; and a hunter is limited to three in the aggregate of canvas-backs, redheads, ruddies and buffle-heads, so the bluebill is the mainstay of the salt-water hunter. In southern California, the species just mentioned are not abundant enough to make good hunting, so the hunter in desperation is apt to shoot scoters, which to say the least are not an epicurean delight.

If the salt-water hunter is in an area, such as the Suisun marshes, frequented by surface-feeding ducks, he may be lucky enough to get a few birds which have been frightened away from duck club grounds. By adding these birds to a canvas-back and a bluebill or two the man who knows the country may make a good bag. Quite a number of hunters carry this to an extreme and try to get ducks by waiting at the edge of a gun club and shooting at the birds as they leave or enter the grounds. This is usually a futile and exasperating pastime, because while thousands of birds may be seen, they fly so high that the hunter has not a chance.

Doves

The estimated kill in 1938 was 1,700,000 doves.

The western mourning dove (*Zenaidura macroura marginella*) is the only dove of interest to California hunters as a whole. The white-winged dove (*Melopelia asiatica mearnsi*) is found in the southeastern corner of the State and is taken in some numbers by hunters in Imperial County. Even in this area it is not nearly as abundant as the mourning dove. The Mexican ground dove (*Columbigallina passerina pallescens*) is a third species which is found in Imperial County, but this tiny bird is not hunted. The ring dove (*Streptopelia risoria*) and the Chinese spotted dove (*Spilopelia chinensis chinensis*) are two imported forms, some of which escaped or were released from aviaries in southern California. These noisy species are now all too well established in the residential areas of several southern California cities and have spread to open country in parts of Los Angeles County.

Mourning doves are common in open country over most of the State at elevations up to 5,000 feet, and are occasionally found as high

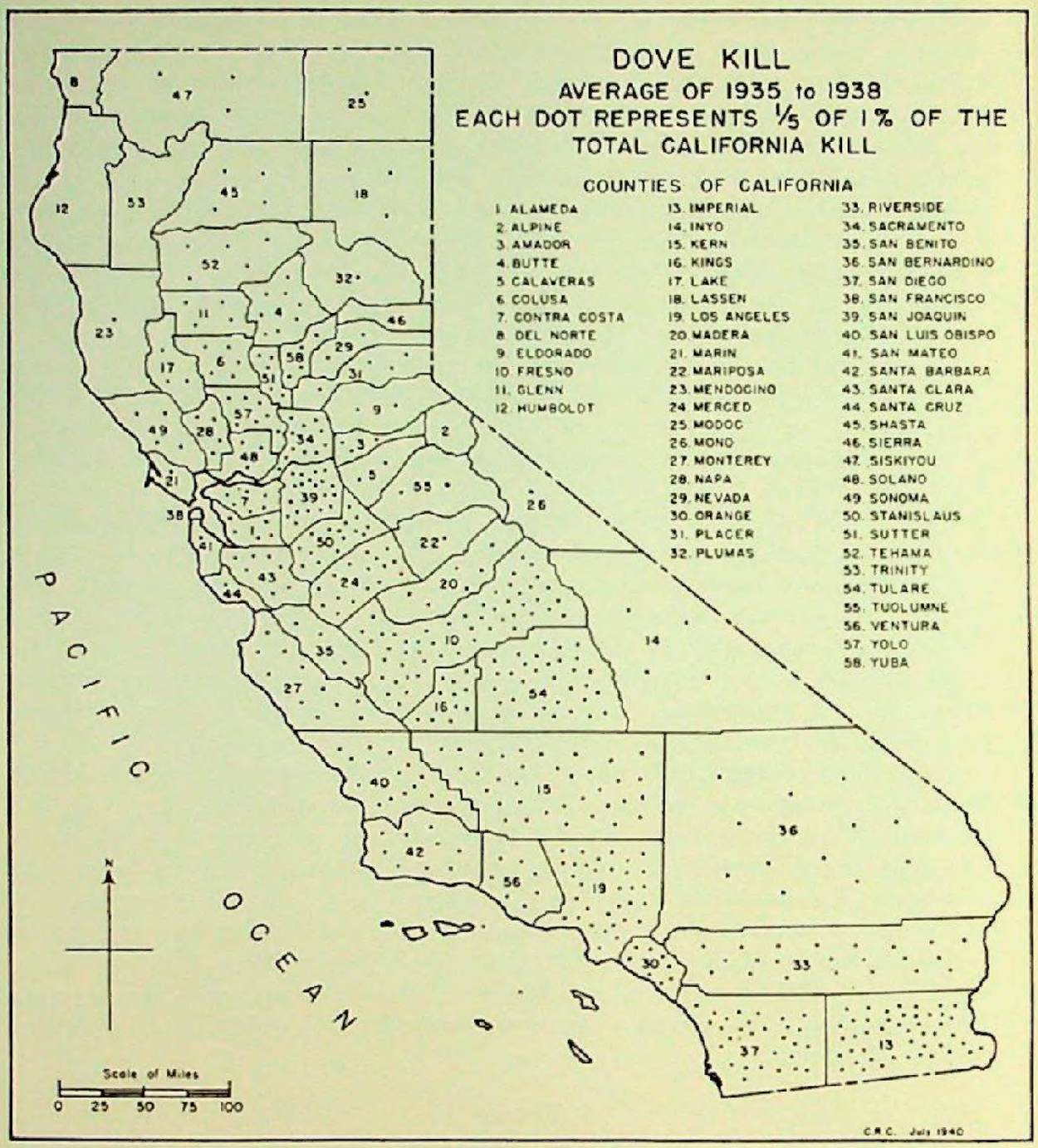

FIG. 113.

as 8,000 feet. Although it is typically an Upper and Lower Sonoran zone bird, the dove does penetrate into the Transition and even into the Canadian zones.

Doves feed in open fields and if no trees are available they may rest and even nest on the ground. They like to perch in trees, particularly on dead branches, and on telegraph wires. They drink regularly, morning and evening, and will go miles to water. Heat has no terrors for doves and they are most abundant in the hot central valleys, i.e., Sacramento-San Joaquin and Coachella-Imperial. On the other hand, the birds generally do not like cold, and a few cold nights are apt to start most of them on a southward migration. This is particularly true if the shooting season is just starting and the doves have this added reason for leaving the country.

Dove hunters use several methods:

"Walking them up" in the fields in which they are feeding. This produces an almost snipe-like target which zig-zags away close to the ground.

Scaring them out of single trees, clumps of trees or wind-breaks. The birds dive out of the trees at varying angles and swoop up again as they put on the power. There is quite a knack to hitting a dove under these conditions and all too many hunters prefer to pot the sitting birds.

Pass shooting. In many places doves have very definite lines of flight and excellent pass shooting is the result.

Waiting for them to come to water. This method is particularly deadly in areas where water-holes are far apart. It would be even more deadly if the doves did not soon learn to wait till after dusk before watering.

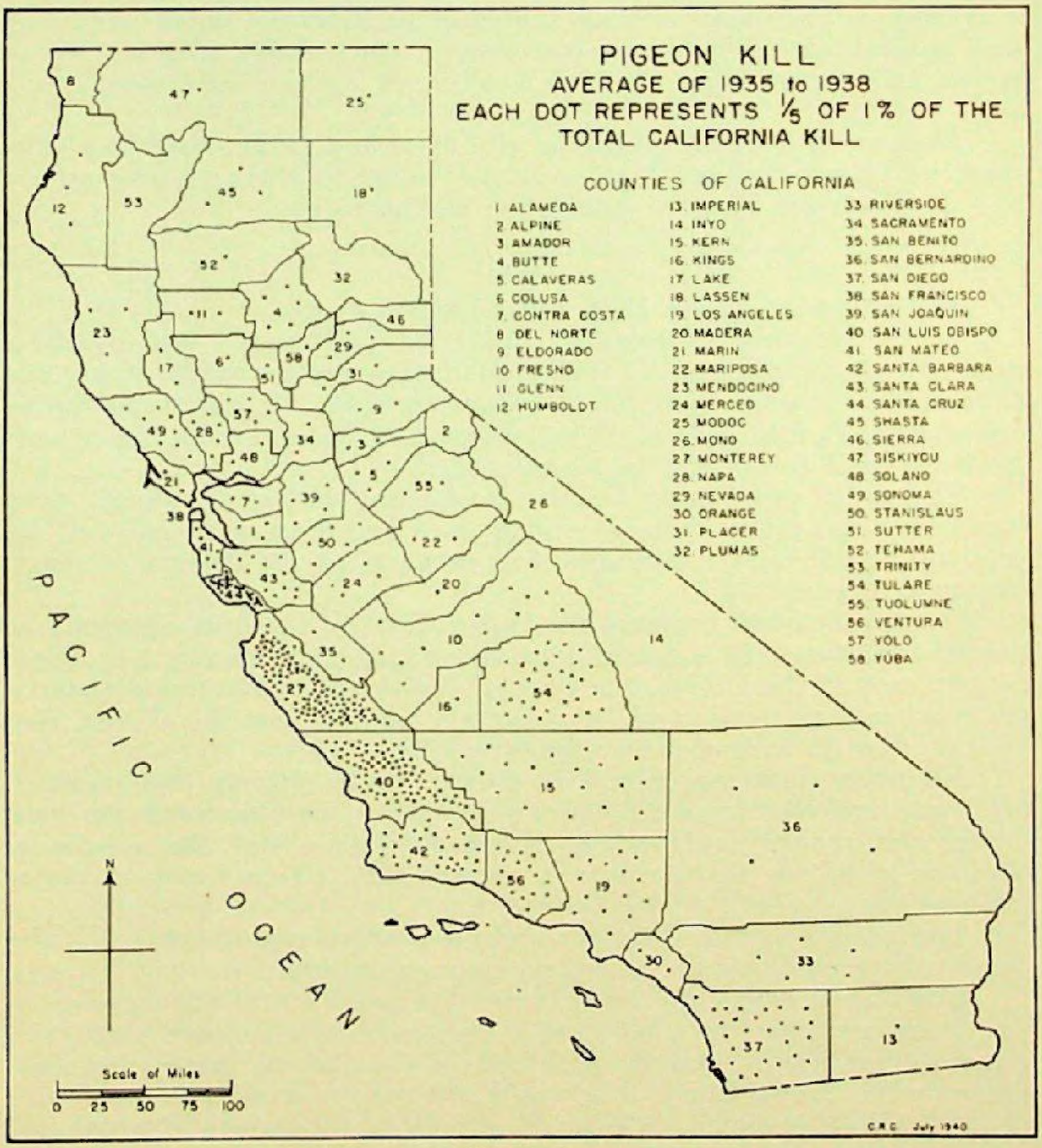

FIG. 114.

Pigeons

The estimated kill of pigeons in 1938 was 95,000.

The band-tailed pigeon (*Columba fasciata fasciata*) is the only wild bird commonly known as "pigeon" in the State. This species is found from the Rockies westward to the Pacific and from British Columbia to Nicaragua. In California it is now most common in the coastal ranges, less so in the Sierra foothills. In the summer the birds are probably most abundant in the mountains of the northwestern portion of the State, but by the time winter arrives the bulk of them has moved into the coastal mountains of Monterey, San Luis Obispo and other nearby counties.

In general they live in the zone of the tan bark oak, golden oak and live oak (Transition and Upper Sonoran life zones). They feed largely on acorns but also take madrone, toyon and other berries.

Pigeons follow the food supply and hence seem quite erratically migratory. They may appear suddenly in numbers in an area they have not visited for years and conversely, a poor acorn crop may result in the pigeons avoiding an area which they have been visiting regularly.

Pigeons do a lot of flying, usually at such a height that they skim over the ridges and sail high over the valleys. Hunters take advantage of this habit by pass shooting from the ridges.

Quail

The estimated kill in 1938 was 1,500,000 quail.

There are three species of quail in California: the mountain quail (*Oreortyx picta*), the valley quail (*Lophortyx californica*), and the desert or gambel quail (*Lophortyx gambeli*). These three species are often split into a total of six subspecies, but for this report only the three basic forms will be considered.

The valley quail is by far the most important of the three. It is found over the entire State *except* in the High Sierras, in parts of the Siskiyou and Trinity mountains, and in parts of the deserts of southeastern California.

The desert quail replaces the valley quail in the southeastern portion of the State. It is found over all of Imperial County, San Diego County east of the Divide, the eastern two-thirds of Riverside County, the southeastern portion of Inyo County, and almost all of San Bernardino County except the southwest corner.

Mountain quail are found in mountainous country over most of the State, usually from 2,500 to 9,500 feet. In the southern coast ranges the species is found at lower elevations and the subspecies which inhabits the moist northern coastal belt is found clear down to sea level.

The ranges of the different species overlap and there are a few places where all three are found on common ground.

Quail need brush for cover, trees to roost in and open grassy or weedy country in which to feed. They will not venture any great distance from cover and do not feed in that cover, hence the edges where brush meets grass and weeds are where quail will be found. Country which is cut up into small islands or peninsulas of brush will have far more "edges" and far more quail than an equal area of land

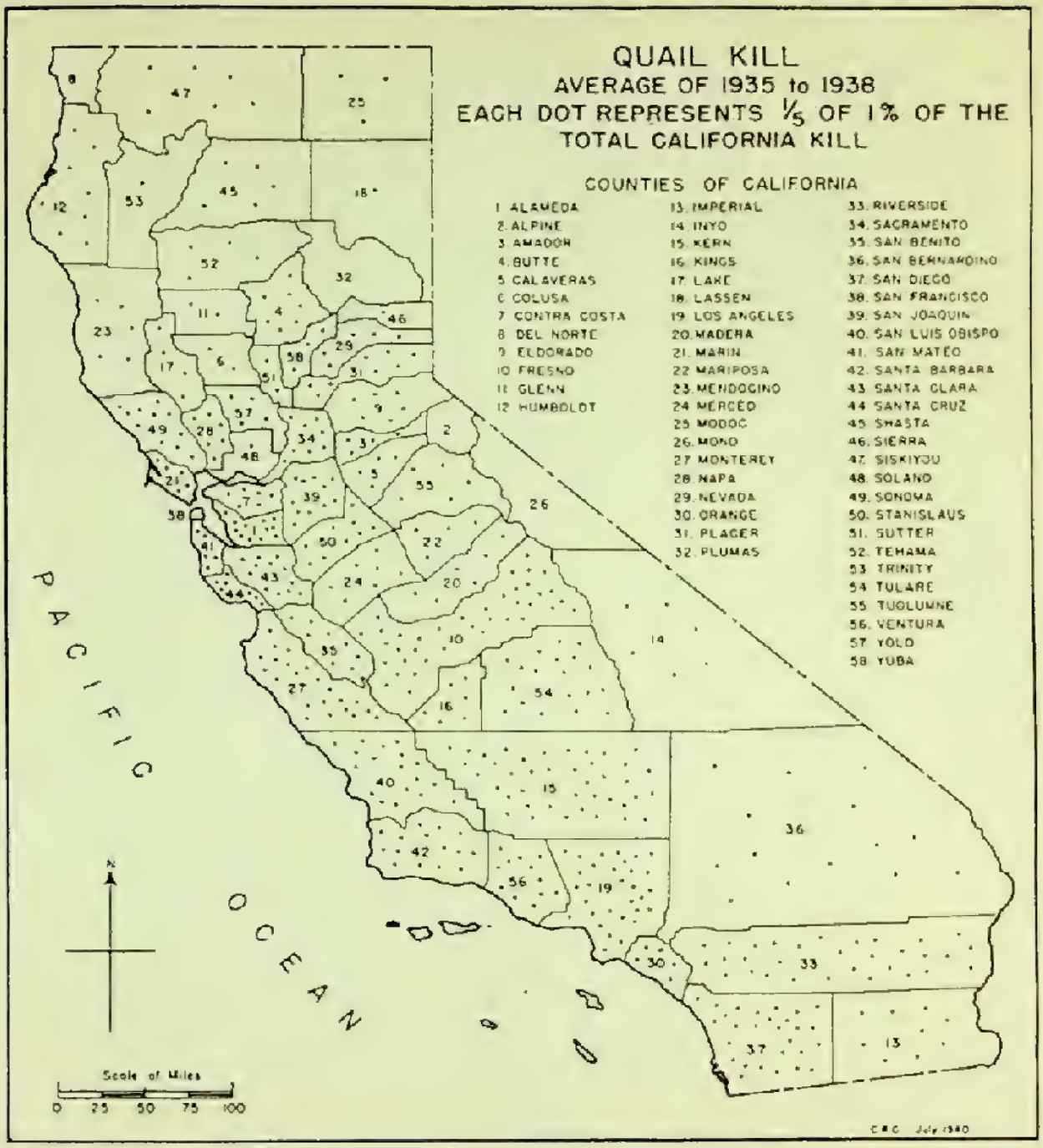

FIG. 115.

which has just one straight boundary line, dividing it into one huge brush patch and an equally large open area. The presence of a few densely foliaged roosting trees is a great asset to quail. Live oaks, sumac, orange and bay trees as well as dense conifers are excellent quail roosts.

Water is required by quail during the dry part of the year, but during the winter and spring they can get along by eating tender green leaves and shoots.

Desert quail use dense patches of high brush such as mesquite, both for cover and for roosting. They are usually found near desert springs, but are able to do with much less water than the other species.

Quail hunters in hilly country will do well to get above the birds, otherwise the quail will run up hill, usually at such a pace that few men can keep up with them. This is especially true of mountain quail.

When on level ground, it is best to get between the birds and the nearest cover whenever possible. Several hunters working abreast can often flush birds that would dodge around one or two men without ever being seen.

While all the quail found in California are foot-racers, the desert quail carries this to an extreme. Often when desert quail have not been shot at very often, it is impossible to make them fly without shooting at them. The birds sprint, zig-zagging away through the brush at a startling speed. Hunters who know desert quail are not at all horrified at the idea of shooting a running bird. On the other hand, men on their first desert quail hunt often start out by insisting that such slaughter is beneath them and wind up by discovering that they can not hit the crazily dodging sprinters.

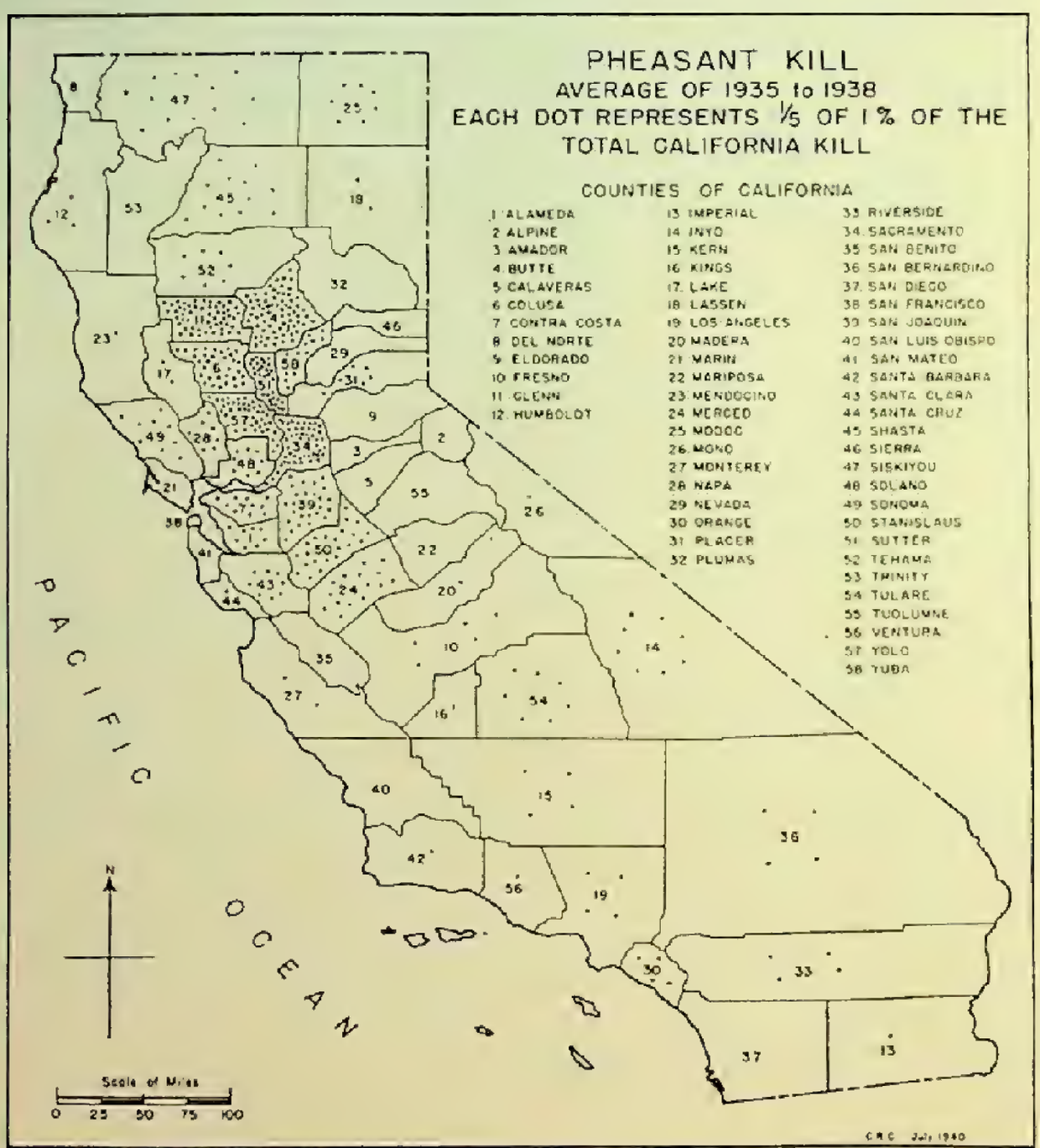

FIG. 116.

Pheasants

The estimated kill of pheasants in 1938 was 125,000.

There are no native pheasants in the western hemisphere (the so-called native pheasant is not a pheasant at all but the western ruffed grouse). Nearly all of the pheasants which have been introduced into California are either Chinese, Mongolian or an intergrade between these two very similar ring-necked forms. A few Reeves pheasants have been liberated, but these timber loving birds are not yet well established.

Pheasants do well in farming country, especially so in the areas where rice is grown. Feeding trips may be as long as two or three miles, but somewhere not too far away the birds must have water and dense ground cover in which to hide and nest. Some cultivated crops—such as asparagus, peppers and alfalfa—are dense enough to make good cover for old birds, but to raise their young the pheasants must be undisturbed for the entire nesting period. Practically all crops that are cut, cultivated or irrigated are unsuited for nesting. Consequently, good pheasant country must have some undisturbed land. Ideal cover is the rank tangle of weeds and scattering brush found along water courses.

Because they nest and roost on the ground, pheasants are somewhat subject to loss by predators. In California, many birds are drowned by flood waters of the Sacramento River and its tributaries. This loss is not as serious as might be imagined, because the floods compensate by drowning relatively more predators than pheasants, and by providing better cover and food conditions after the water has receded.

Pheasant hunting is best in the well watered areas of the Sacramento Valley. Several hunters walking abreast across a field can often jump birds which would be overlooked by one or two men. Any active dog will flush many birds which would otherwise have remained hidden, and even an untrained pup is a big help if he will stay close to his master. One of the big mysteries of pheasant hunting is how such a huge gaudy bird can vanish in cover that looks too sparse to hide a quail.

Cottontail and Brush Rabbits

The estimated kill of cottontail and brush rabbits in 1938 was 500,000.

California's most common cottontail is *Sylvilagus audoboni*, and the common brush rabbit is *S. bachmani*. These two species probably account for over 99 per cent of the cottontail and brush rabbit kill of the State. Besides these two, there are the Washington cottontail (*S. nuttallii nuttallii*), whose range extends into the northeastern corner of the State; and the Black Hills cottontail (*S. nuttallii grangeri*), the range of which reaches the mountains in eastern Inyo and Mono counties.

Cottontails (*S. audubonii*) are usually found either in Lower or Upper Sonoran life zones below 4000 feet elevation. In the San Bernardino Mountains, they have been recorded as high as 6000 feet.

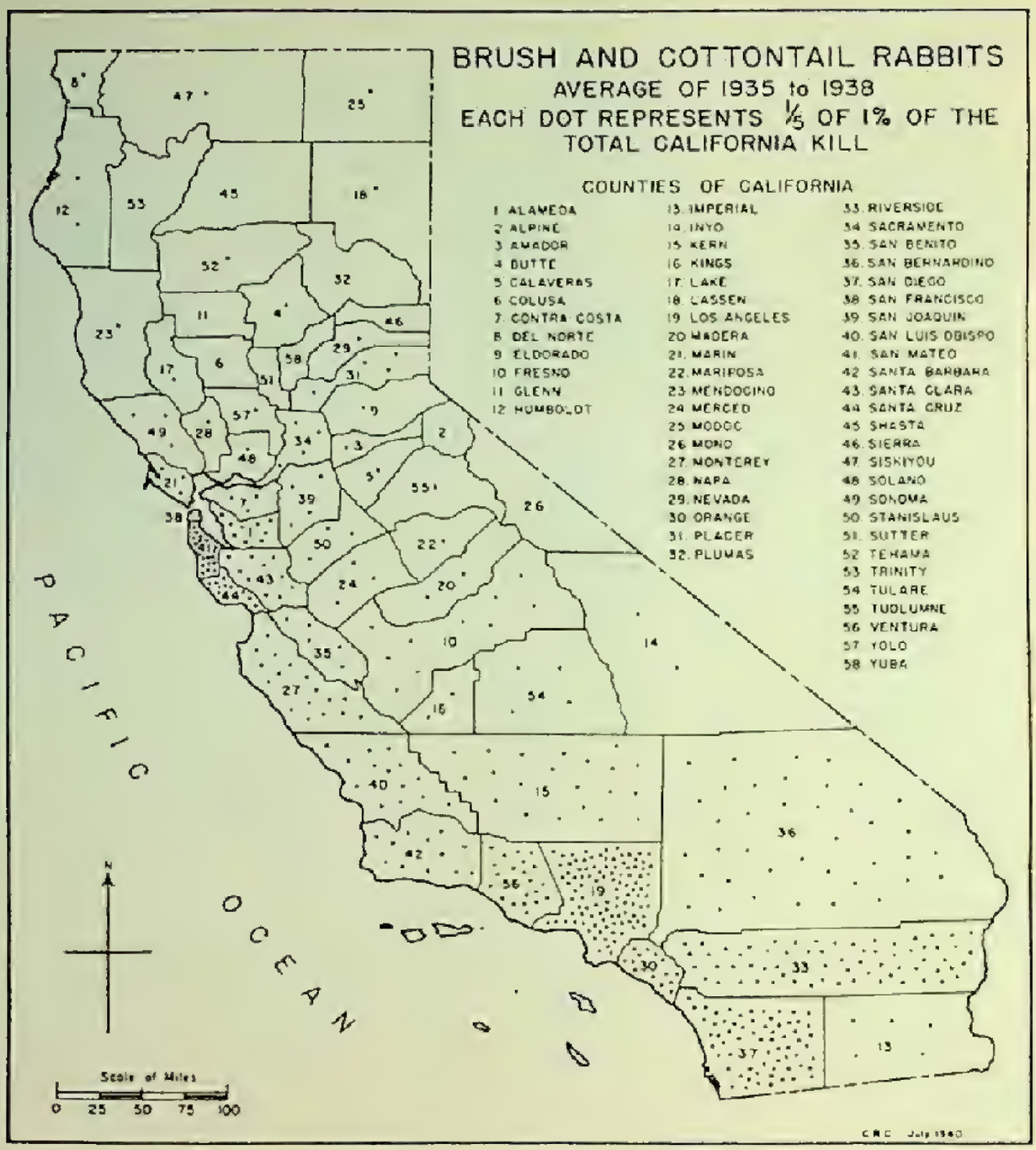

FIG. 117.

Valleys and river bottoms with scattered brush patches are typical cottontail country. They also do far too well around vineyards and truck gardens.

The brush rabbit (*S. bachmani*) is typically an Upper Sonoran or Transition life zone animal. One subspecies (the redwood brush rabbit, *S. bachmani ubericolor*) chiefly inhabits the Transition zone, but is also found in Upper Sonoran country. The usual altitude range is from sea level to a little over 4000 feet, though the species is apt to go higher than this in southern California. Chaparral and other thick brush and the edges of forests are typical brush rabbit country.

Many rabbits are killed by quail hunters, since the two kinds of game are often found together and since quail hunting methods work very well on rabbits. In good country, rabbit hunting is not an

involved pastime. All the hunter needs to do is to take a morning or evening stroll, keep his eyes open and his gun ready and perhaps kick through a few isolated brush patches. If the brush is too thick and the rabbits are too wary, a good rabbit dog will make the difference between seeing none and getting several.

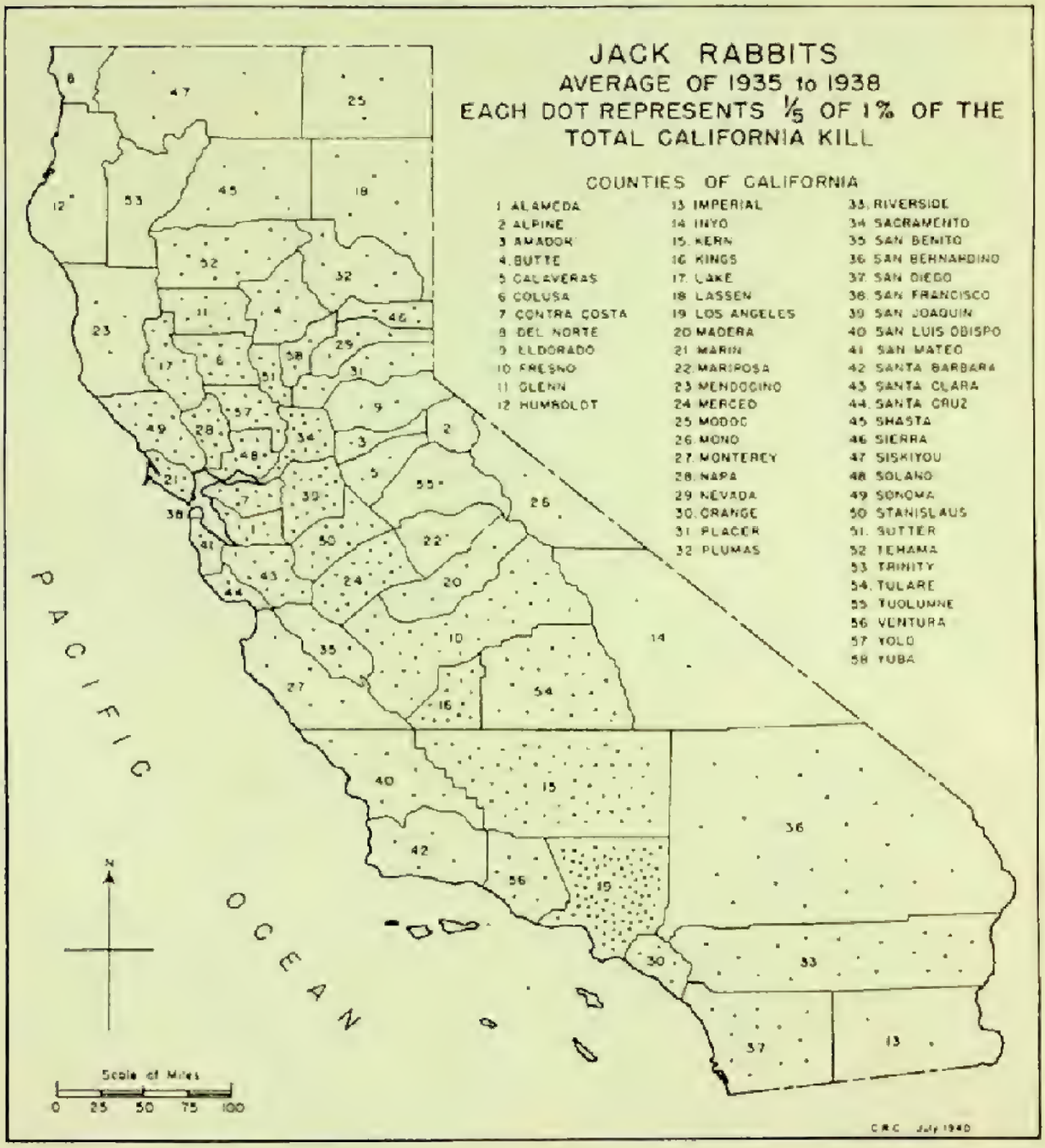

FIG. 118.

Jack Rabbits

The estimated kill of jack rabbits in 1938 was 750,000.

The black-tailed jack rabbit (*Lepus californicus*) is *the* jack rabbit of the State and is the only one which is specifically listed as being open to hunting. Five subspecies of black-tailed jack rabbits inhabit California but in this report no attempt will be made to treat them separately.

Some western white-tailed jack rabbits (*L. townsendii townsendii*) are found in the northeastern corner of the State.

The Sierra hare (*L. townsendii sierrae*) is a white-tailed form which is found in the central and southern Sierra Nevada Mountains. This subspecies is given complete legal protection.

There are a few snowshoe rabbits (*L. washingtoni*) in the northern and central Sierra Nevadas and in the Trinity and Siskiyou mountains.

Black-tailed jack rabbits characteristically live in the Upper and Lower Sonoran life zones, but often enter the Transition and occasionally even the Boreal zones.

Grassy or sage-covered plains and slopes are typical jack rabbit country but the creatures are often quite common in open forest, open chaparral or around clearings. Alfalfa fields, grain fields and vineyards make excellent jack rabbit country as every farmer knows to his sorrow.

Over most of the State, 6,000 feet is about the maximum altitude reached by these animals, but in the White Mountains of Mono County they have been seen as high as 12,500 feet.

Jack rabbits are not regarded as game animals in California although a hunting license is required. In many areas they are a serious pest and as such are shot by nearly all hunters whenever and wherever one of them happens to get within range. Many ranchers carry a gun in the car at all times for the purpose of "knocking over a few jacks." In parts of the Sacramento-San Joaquin Valley, ranchers sometimes resort to huge rabbit drives to keep them thinned down. Hundreds of men drive thousands of rabbits into a specially built corral and club them to death.

Deer

According to the deer tag reports, the deer kill in California in 1938 was 35,045.

There are two species of deer in California. One of these (the mule deer) is further divided into six subspecies.

The northwestern white-tailed deer (*Odocoileus virginianus ochrourus*) is found in northeastern Nevada, northward east of the Cascades into British Columbia. It is exceedingly rare in California.

The Rocky Mountain mule deer (*O. hemionus hemionus*) has a very wide distribution in western United States and Canada. In California its range includes the northeastern part of the State. East of the Sierras, its range extends south to Mono County.

The California mule deer (*O. h. californicus*) is found on the western slopes of the Sierras from El Dorado County southward. It is also found in the Tehachapis and in the coastal mountains from Orange County to southern Monterey County.

The Columbian black-tailed deer (*O. h. columbianus*) is found along the coast from central California to central British Columbia. In California it is found in the coastal ranges south into Santa Barbara County and in the western part of the Sierras south to Tuolumne County. Its range occupies practically the entire western two-thirds of that portion of the State which lies north of the Sacramento Valley.

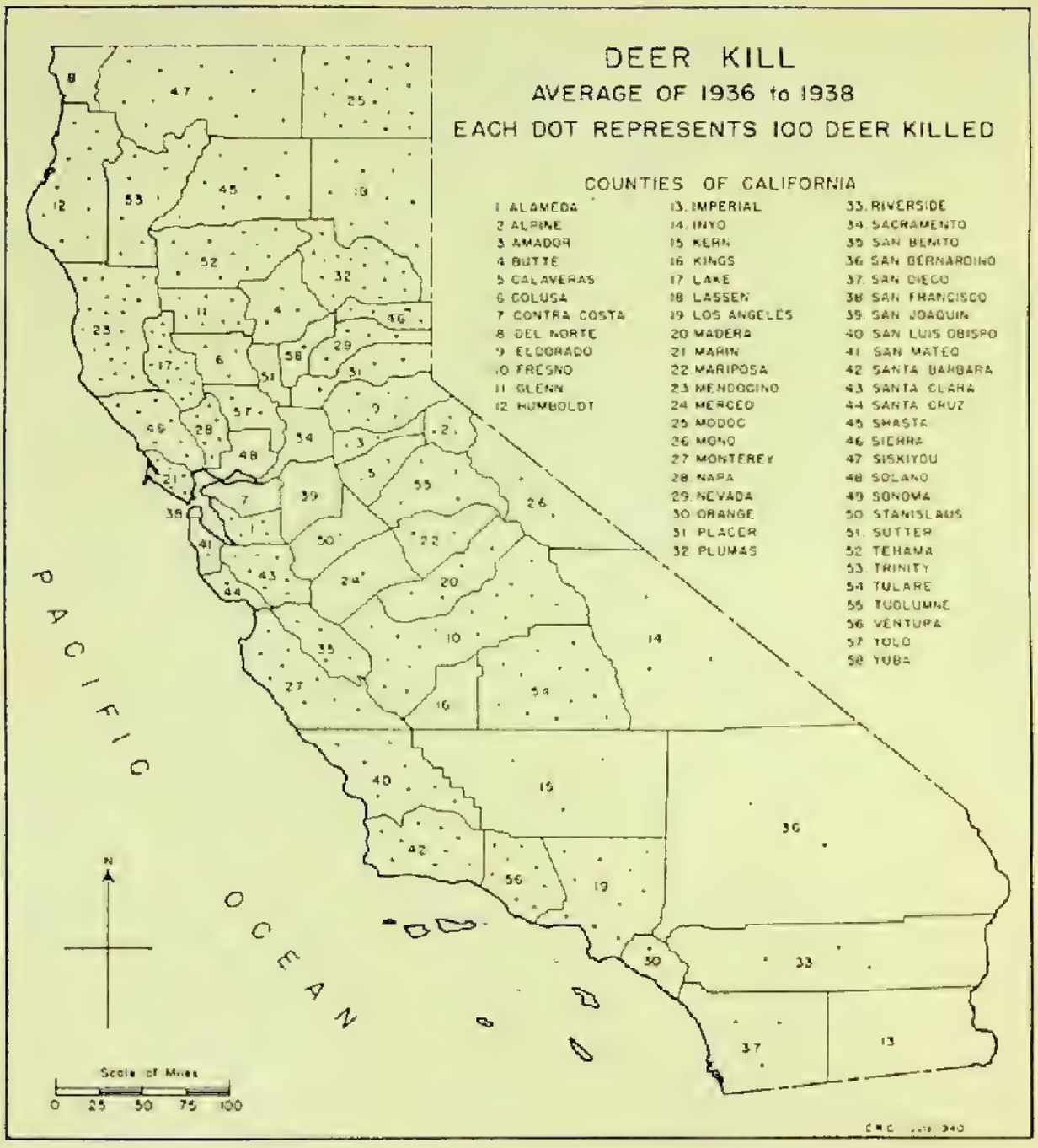

FIG. 119. Note that the deer map shows actual numbers of deer killed instead of expressing them as a percentage of the State total.

The Inyo mule deer (*O. h. inyoensis*) is found in Inyo County and southern Mono County from the eastern slope of the Sierras into the White Mountains.

The southern mule deer (*O. h. fuliginatus*) is found in the mountains of western Riverside County, south through San Diego County into Lower California, Mexico.

The burro deer (*O. h. eremicus*) is found near the Colorado River in eastern Riverside and Imperial counties. Its range extends eastward into Arizona and southward into Mexico.

There is much overlapping of deer ranges in California and there are large areas where more than one form may be found.

In California deer are most common in hilly or mountainous areas with patches or large areas of woods or brush. They feed on the leaves

and tender shoots of trees and shrubs and at times eat a great deal of grass. Acorns are a valuable deer food. Deer can stay inside large brushy areas and feed on the terminal foliage only if the foliage is low enough for them to reach, otherwise they must feed around the edges of clearings where the leaves and shoots are closer to the ground. As a result, the best deer country is broken into small clearings and brush patches.

Deer hunting in California is usually done in more open country than in the East, and longer shots are the rule. Probably, the most usual hunting method is for the hunter to walk quietly through good country and periodically slip into some extra good view point and watch a deer trail, a spring or the edges of brush and timber patches until he feels sure that nothing is apt to appear. It isn't necessary to be absolutely hidden, but it is better to be in dense shade and not to move too much. It is also advisable to pay attention to the direction of the wind. Another variation of this method is for the hunter to get into a good place and then send his assistant—either human or canine—into some likely looking brush patches. Sometimes this method is expanded and a group of hunters will attempt to drive deer past one or two of their numbers, but deer drives on the scale used in some of the southern states are practically unknown in California. Other methods used less frequently are trailing them down with or without dogs and bucking brush in the hope of jumping one at close range.

THE COLLECTION, COMPILATION AND ANALYSIS OF GAME KILL STATISTICS

As already mentioned, the man who can best estimate the kill of any given hunter in a season is that hunter himself, and a logical time to ask him seemed to be when he purchased his hunting license. Accordingly, the Division of Fish and Game issued license application forms, each with a questionnaire attached. This printed questionnaire lists the species and asks the hunter to record how many of each he took and in what counties during the previous hunting season.

The license applications and questionnaires are sent to the statistical department of the California State Fisheries Laboratory for tabulation. A small proportion is the product of the would-be humorist and is eliminated. Honest mistakes (such as recording doves in the space for deer) are corrected if there is no possible doubt as to what the hunter meant. The information from the usable records is transferred to punched cards which are sorted and tabulated by machinery.

This method has been in use since 1935 and is a tremendous improvement on the older method of relying on the conflicting reports of a few score wardens and interested hunters scattered throughout the State. The records from the license applications show a great many things, only part of which are discussed in this paper. For example, they can and do show the relative importance of all the counties of the State and whether or not the kill of a certain species is increasing or decreasing in a certain area. Although such records are very valuable and although the method represents a big step forward, the license application system has some major disadvantages:

The individual records are very poorly made out, a long time must elapse before the records can be compiled, and by itself the system will not give total kill figures that we can assume are even approximately correct. The latter defect, while important, is not as vital as it might seem since relative changes from place to place and season to season are more important than absolute figures.

To realize why the individual records are poor, it is necessary to know the conditions under which the questionnaires are filled out. Most hunting licenses are sold by sporting goods stores. A hunter rushes in to buy his license and shells. He has been thinking about other things and is somewhat confused by the rather detailed questionnaire before him. On such short notice, he can not recollect what he shot the previous year, he does not want to make himself conspicuous by taking too long while trying to remember, and he may be in a hurry. The net result is that only one-fourth of the hunters record any kill at all and that many of those are too hurried to do a good job. The number and quality of the answers obtained in any one store depend to a great extent on the attitude of the clerks. Some take an active interest and try to get every customer to fill out the blank. A few go to the other extreme, but the majority makes no great effort to influence the customer in either direction. In some of the smaller counties the number of places selling licenses is very limited, and the attitude of one or two men may make a tremendous difference in the number and quality of the questionnaires received from that county. As a result the percentage of usable questionnaires from the individual counties varies from 10 to 50 per cent. Obviously, this makes it necessary to factor the kills of the hunters from the different counties to a common level. After this factoring is done, the kills are re-sorted and added to give (for example) the quail killed in Los Angeles County instead of the quail killed by the Los Angeles County hunters.

Another difficulty is the length of time that must elapse before the records can be compiled. The 1939 hunting season ended with the close of the year. In July, 1940, the hunters started buying their next licenses, and they will continue buying almost until the first of the next year. Thus, it will be 1941 before it will be possible even to start working on the 1939 reports. A related disadvantage is that there are men who hunted last season, who for some reason will not buy a license this season. Obviously, these men will not be reached by a license application questionnaire, but if the system worked well in most other respects it would not be hard to estimate their kill. Unfortunately, there are other factors which work against securing accurate total kill figures. For example, if the method were used by itself we would have no way of knowing whether the *average* hunter who answers the questionnaire exaggerates his kill, gives a good estimate or makes an understatement. In addition, the method used alone will not show whether or not the hunters who do fill out the questionnaire have anything like the same average kill as those who do not give us a record.

Fortunately, we have a fairly good way of reducing the error caused by these two difficulties: When a hunter kills a deer he is

required to fill out a card in duplicate, attach one to the buck's antlers and mail the other to the California Division of Fish and Game. This gives us reasonably accurate figures on the deer kill, and if we could assume that the questionnaires' record of small game was no better and no worse than its deer kill record, we could calculate the small game kill with fair accuracy. However, we can make no such assumption. The man who killed a deer will usually record it—he remembers that the Division has a record of his buck, and he has a vague feeling that he may be checked on, so the deer gets onto the questionnaire. On the other hand, the man who got only small game is more apt to pass by the questionnaire. The net result of these factors is that over three-fourths of the deer are reported by the one-fourth of the hunters who record any kill at all.

We know that the recording hunters were successful hunters, and that many of those who did not record anything actually killed nothing,[2] so we know that the one-fourth of the hunters who did report game got far more than a fourth of all the game.

On the other hand, no small game was as well recorded as deer, so we know that although the recording hunters took over three-quarters of the deer, they undoubtedly took less than three-quarters of the small game.

Briefly, all we can say is that the recording hunters took well over one-fourth of the game and something under three-fourths of it. This is too wide a range, and we do not feel justified in estimating the actual kill without refining the method.

In the hope of getting away from some of the disadvantages of the license application system, a different method was given a trial at the end of the 1938 season. A special questionnaire was mailed to one out of every ten hunters who had purchased a hunting license during 1938. About 23,000 of these were delivered by the Post Office. The questionnaire asked each hunter what he had taken during the season just past and in what counties. The form used was essentially the same as that on the license application, but there were several advantages over the older method. The hunter received the mailed questionnaire at the close of the season when that season was still distinct in his mind, not six to ten months later when the last season's kill was beginning to become vague and mixed up with that of the two or three previous years. He was not hurried in filling out the form. He was not buying a license and did not have to sign the blank; hence there was much less feeling of being checked on and much more tendency to treat a deer as just another animal, rather than as something special that had to be recorded if he was to keep out of trouble. Finally, if he was interested enough to fill out the blank and mail it, he was in all probability interested enough to fill it out properly.

This last effect was very noticeable—instead of a tremendous mass of very poorly filled out blanks, we received a much smaller number, but the individual blanks were filled out with far more care.

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[2] A special questionnaire was mailed to 11,000 *fishermen* who had failed to fill out their angling license application questionnaires. This indicated that a little over half of the non-reporters actually had no catch. No such questionnaire has been sent to hunters, and although the angling figures can not be directly applied to hunting they do give a general idea of what may be expected.

Of the hunters who received the mailed questionnaire, 26 per cent reported their kills, and another 3 per cent reported that they had made no kill. Instead of reporting over three-fourths of the deer, these men reported only 58 per cent of the deer kill that 23,000 hunters should have made. Evidently, there was much less tendency to give deer preferred treatment. Probably, the men who reported 58 per cent of the deer kill actually took somewhat less than 58 per cent of the small game. We have no way of measuring how much less, but this figure can be used as a basis from which to calculate probable minimum kills of all species of game.

Some of the relative advantages and disadvantages of the two systems are as follows: The mailed questionnaire makes it possible to compile the records a year sooner and should give a better total kill estimate. The individual records are far better, and the proportion of returns from county to county is much more uniform, thus reducing the errors which arise when correcting for drastically different returns from different counties. The chief disadvantage of this method is that the number of records received from some of the smaller counties is too few to give reliable county by county records. The obvious solution is to send relatively more questionnaires to the smaller counties in the future.

The chief advantage of the older (license application) system is that it furnishes us with many more records, so that it is possible to check the percentage of each species taken in the smaller counties with more accuracy.

There is one important piece of information which we are unable to obtain from any method which we have used to date: Is there a tendency for the average hunter to exaggerate his kills of small game relatively more or relatively less than his kill of deer? Suppose, for example, that a conscientious hunter kills two deer and 50 doves. He remembers the two deer and records "2 deer." He did not count the doves but he knows he shot quite a few. Is he more apt to record 30 doves, 50 doves, or 150 doves? If he thinks back trip by trip, he will probably come quite close to the actual total, but if he merely guesses, what is he most apt to guess? Is he more apt to add a few to his kill for good measure, or to be overly modest and subtract some?[3] For the present, we are assuming that the average hunter who answered the mailed questionnaire did not exaggerate his kill of small game appreciably more or less than his deer kill.

Comparison Between the Results from License Applications and Mailed Questionnaires

For the year 1938, we have compiled the results not only of the mailed questionnaires but of the license applications as well. Since the deer kill figures are compiled every year from the deer tags, we have this third and far more accurate method to serve as a check on the other two methods.

[3] A large number of very skillfully conducted personal interviews might throw some light on this problem, but at present we are not prepared to carry out such interviews.

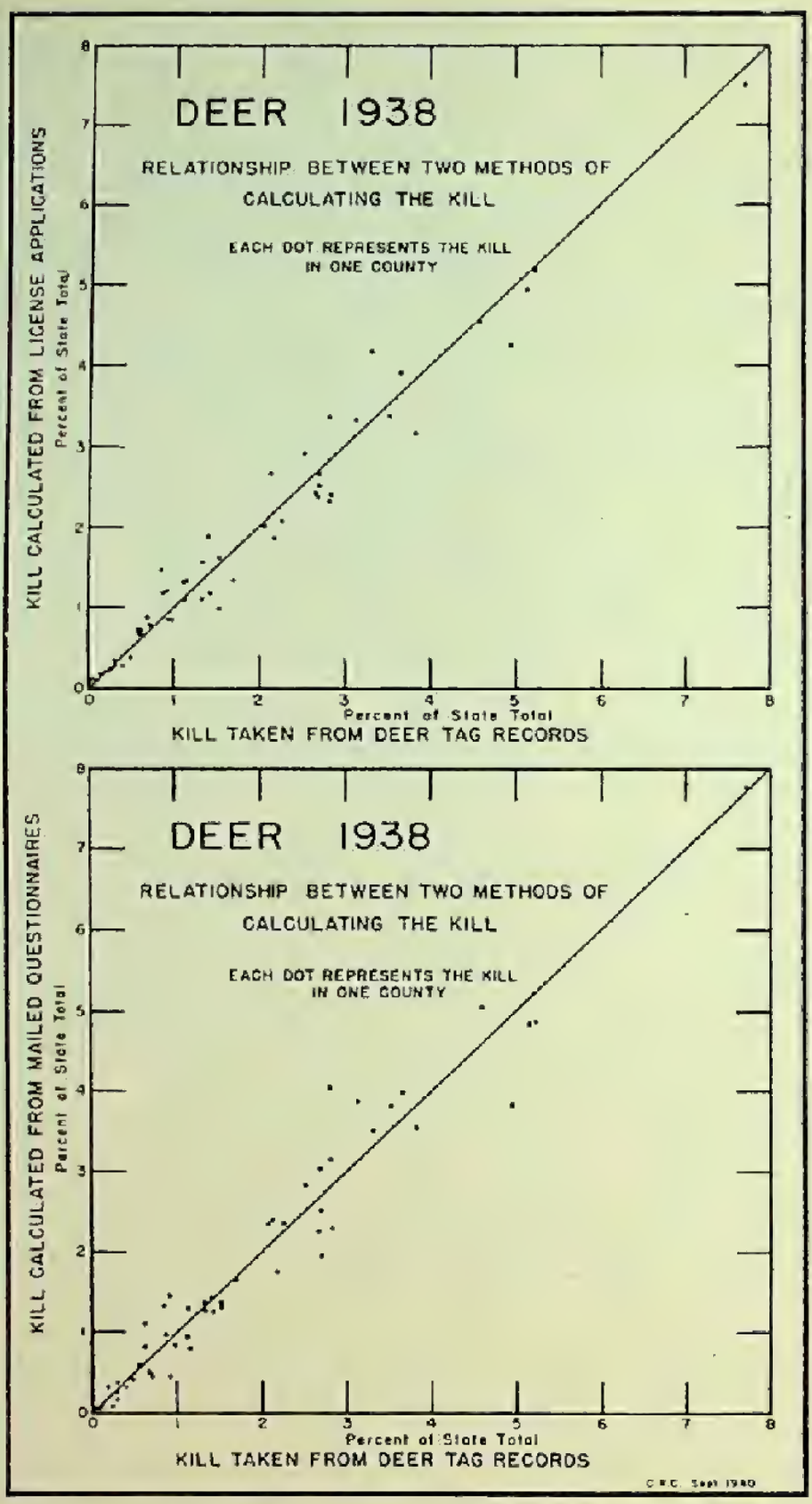
DEER 1938
RELATIONSHIP BETWEEN TWO METHODS OF CALCULATING THE KILL
EACH DOT REPRESENTS THE KILL IN ONE COUNTY
KILL CALCULATED FROM LICENSE APPLICATIONS
Percent of State Total
KILL TAKEN FROM DEER TAG RECORDS
Percent of State Total
DEER 1938
RELATIONSHIP BETWEEN TWO METHODS OF CALCULATING THE KILL
EACH DOT REPRESENTS THE KILL IN ONE COUNTY
KILL CALCULATED FROM MAILED QUESTIONNAIRES
Percent of State Total
KILL TAKEN FROM DEER TAG RECORDS
Percent of State Total

FIG. 120. Relationship between the deer kill as shown by the deer tags and the two questionnaire methods. If agreement were perfect, all the points would be on the diagonal lines. The applications show definitely superior results only in the counties where the kill is less than one per cent of the State total. Most of these counties have small populations and would receive a larger number of mailed questionnaires in any future analysis by this method.

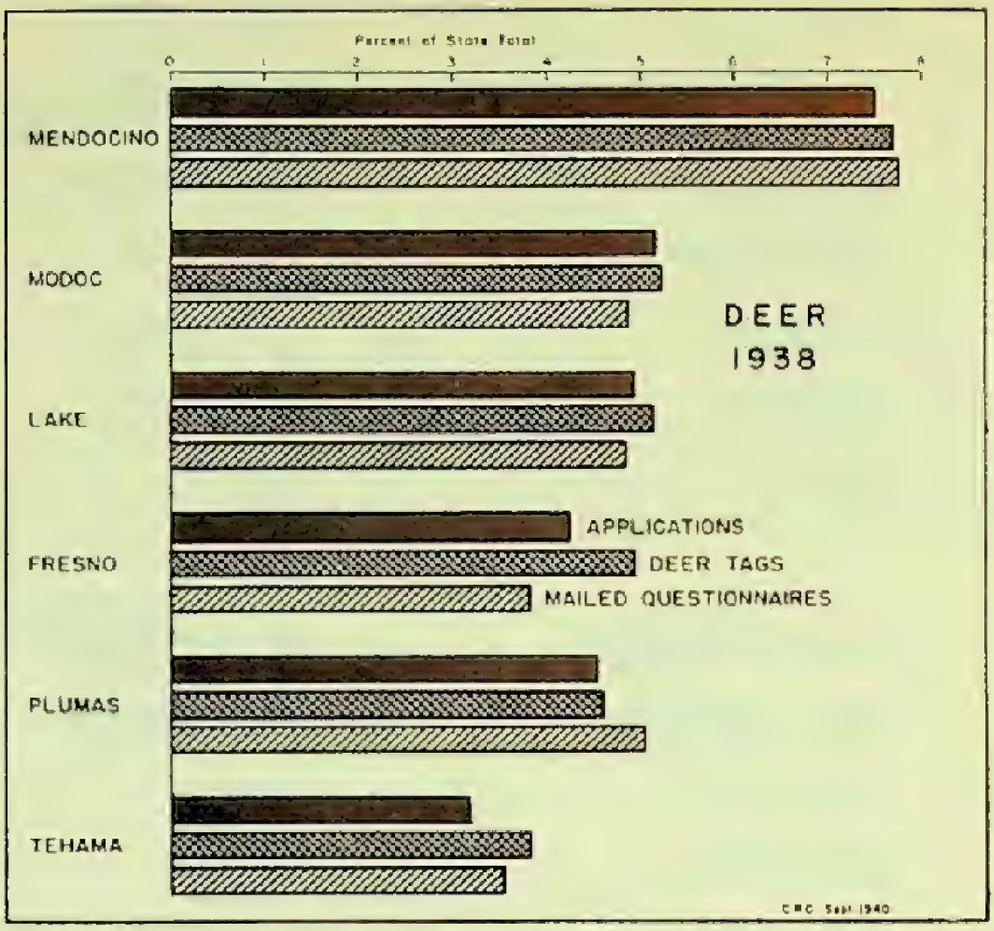

FIG. 121. The 1938 deer kill in the six leading counties shown by each of three methods. The deer tags undoubtedly give far more accurate results than either of the other methods.

Figures 120 and 121 show how the county by county deer figures obtained by the two questionnaire methods compare with the deer tag results. The applications show a higher correlation with the deer tags than do the mailed questionnaires: $r = .983$ as compared to $r = .976$. This difference is slight and is not statistically significant. Several things should be borne in mind when making this comparison: Deer are more carefully recorded on the applications than any other species, thus tending to increase the accuracy of the application deer record. The deer kill is much lower than that of the other species, and a mailed questionnaire large enough to adequately sample the other species might well be a trifle too small to give adequate deer records. Finally, the most noticeable difference between the two charts is in the counties where the kill is less than one per cent of the State total. Most of these counties have small populations, and over three-quarters of the ones which the mailed questionnaires throw most seriously out of line, are counties which would receive a larger number of mailed questionnaires in any future analysis by this method.

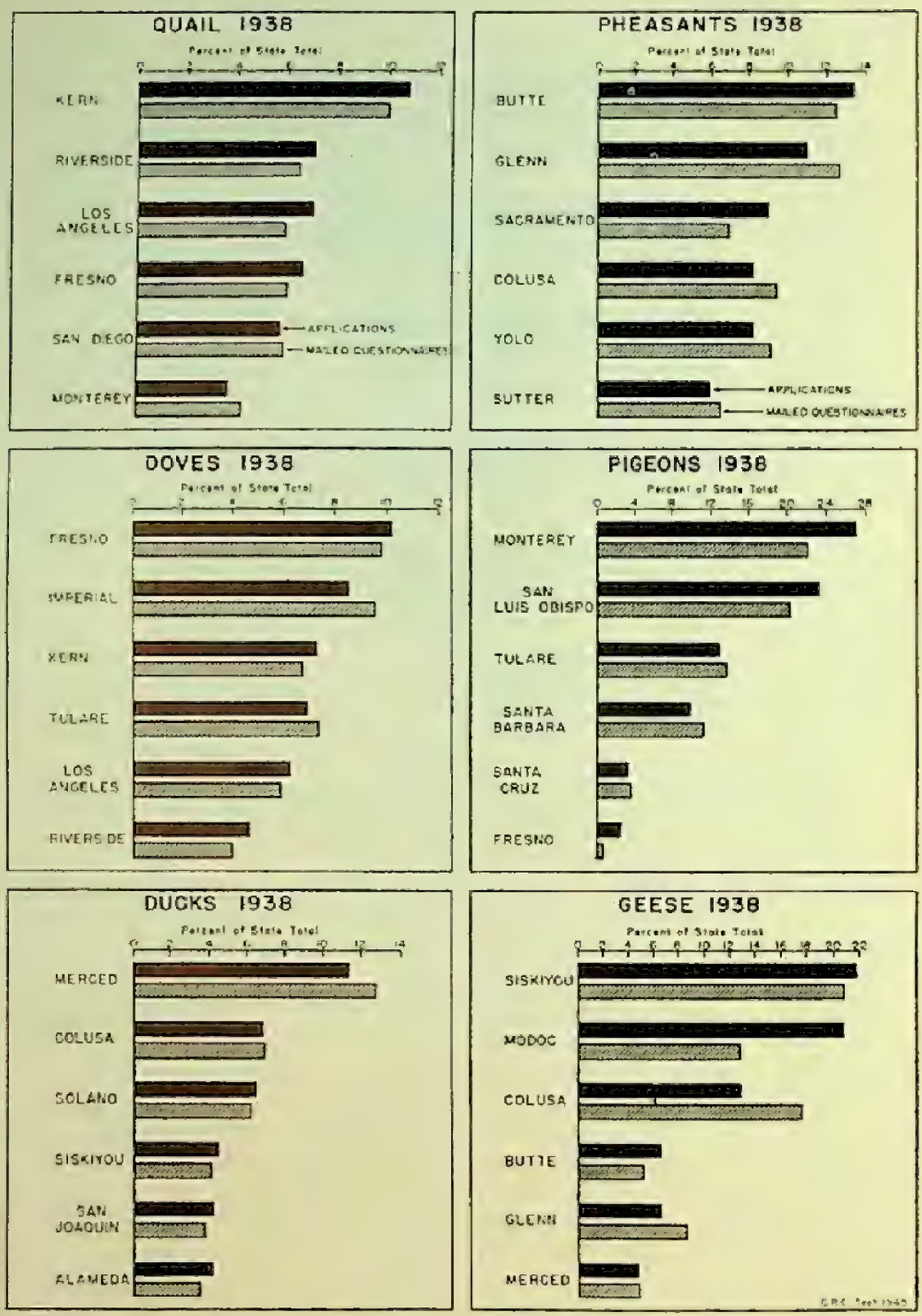

FIG. 122. Kills in the leading game bird counties calculated by two methods. The gross disagreement in the goose kill of Modoc County is due to the fact that no out of state hunters received mailed questionnaires. About one-third of the Modoc County geese were killed by Oregon hunters.

Figure 122 shows the leading counties for each species of game bird. The counties are placed in descending order according to the ratings of the license application system. This figure gives an approximate idea of the amount of disagreement between the two systems, but we have no way of knowing which system is nearer the truth. Figure 123 shows the dove kill in all the counties and figure 124 makes a similar comparison for ducks. Figure 125 shows the leading rabbit counties.

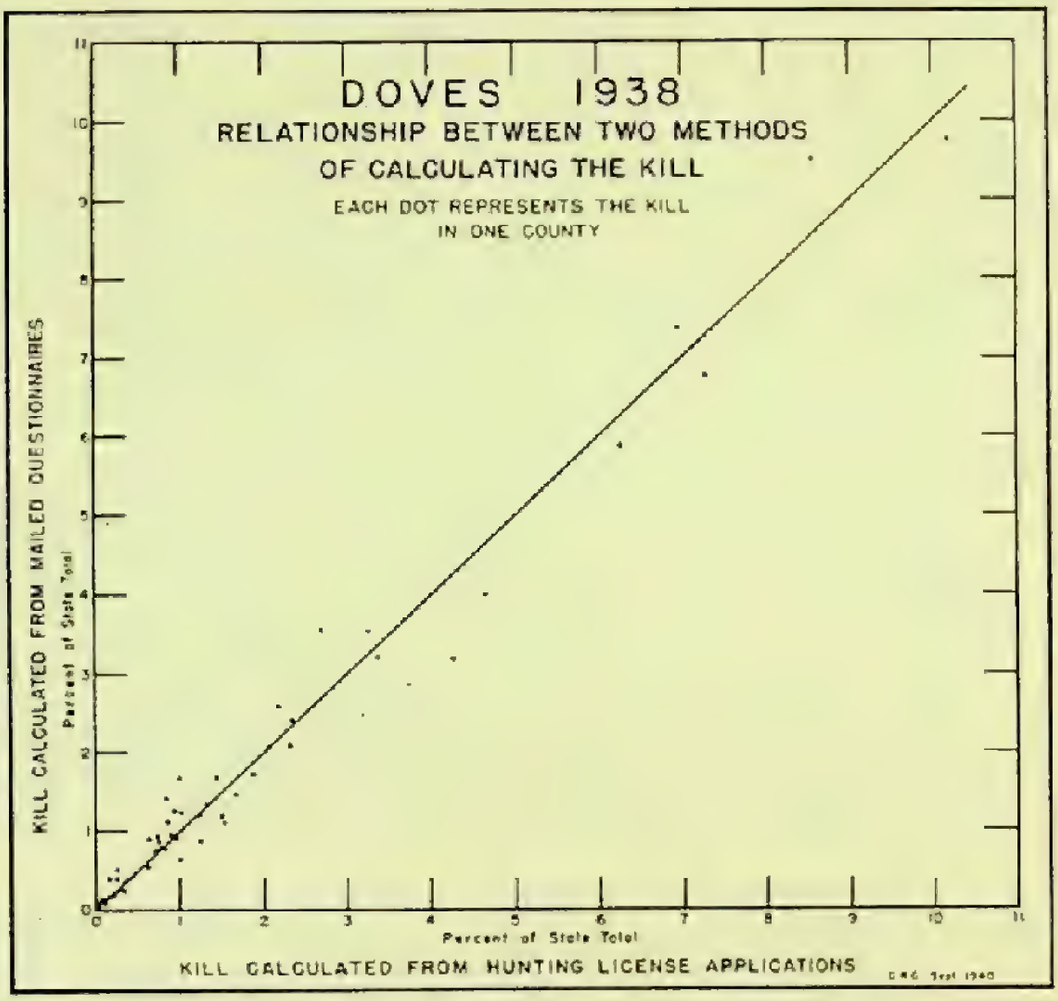

FIG. 123. The relationship between the dove kill as shown by the license applications and mailed questionnaires. Doves, quail, pheasants, pigeons, and cottontail and brush rabbits all show about the same degree of association.

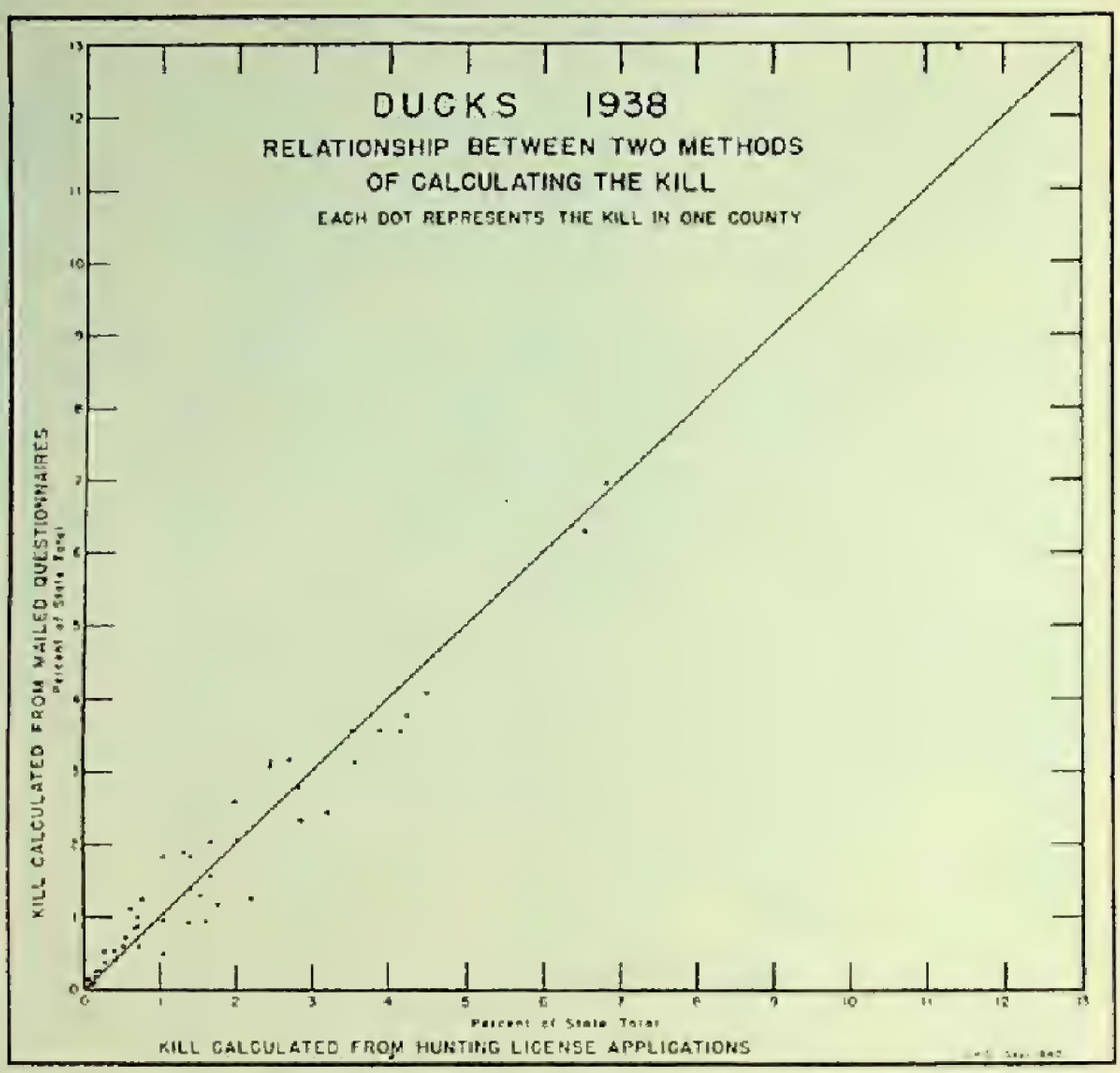
DUCKS 1938
RELATIONSHIP BETWEEN TWO METHODS
OF CALCULATING THE KILL
EACH DOT REPRESENTS THE KILL IN ONE COUNTY
KILL CALCULATED FROM MAILED QUESTIONNAIRES
Percent of State Total
KILL CALCULATED FROM HUNTING LICENSE APPLICATIONS

FIG. 124. The relationship between the duck kill as shown by the applications and by mailed questionnaires. If agreement were perfect all the points would lie on the diagonal line. Ducks show a lower correlation than most of the species.

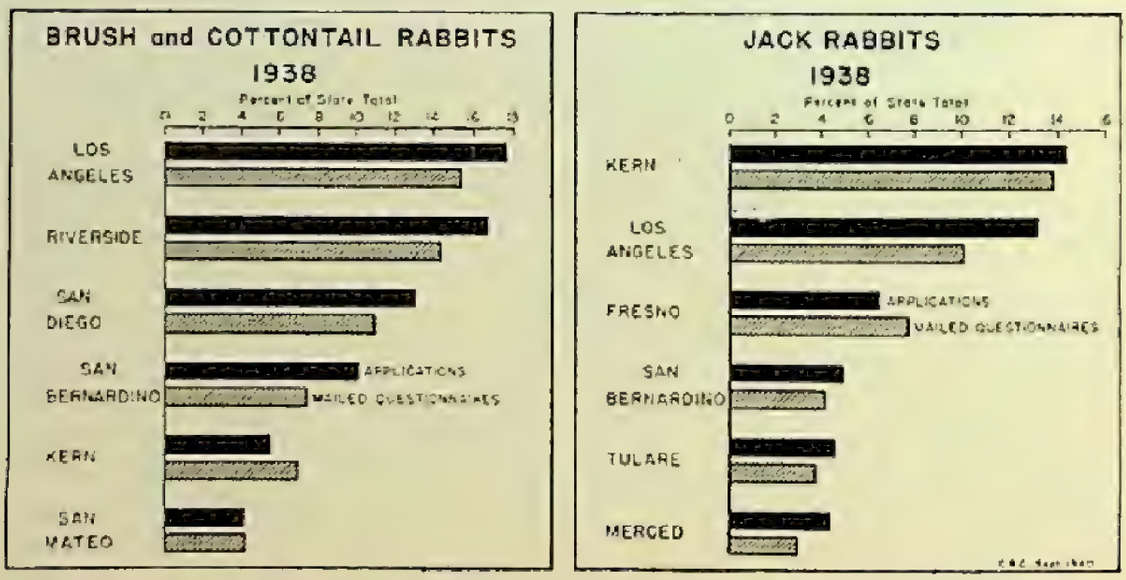

FIG. 125. Leading rabbit counties. The kills are calculated by two different methods.

The correlation between the two methods is as follows:

	r	z
Cottontail and Brush Rabbits	.990	2.65
Quail	.988	2.55
Pigeons	.988	2.55
Doves	.987	2.50
Pheasants	.986	2.46
Ducks	.978	2.25
Jack Rabbits	.957	1.91
Geese	.952	1.85

The standard error of the difference between the z values is 0.20 in every case.

The correlations shown by quail, pheasants, doves, pigeons, and cottontail and brush rabbits are very closely grouped. The jack rabbit and goose correlations are significantly below the level of the first group. The duck correlation lies between the two groups and is not significantly different from either.

The goose correlation is low, at least partly, because of an oversight in planning the mailed questionnaire investigation. No questionnaires were sent to hunters who did not reside in California. Many Oregon hunters shoot in Modoc County and in 1938 they shot roughly one-third of all the geese taken in that county. These geese were not reported on the mailed questionnaires, and as a result Modoc, one of the leading counties, was so far out of line as to reduce the correlation.[4] The omission of Oregon hunters also had a similar but very much smaller effect on the duck figures for the State as a whole. The effect of out of State hunters on the deer, rabbit and upland bird correlations can be disregarded.

By eliminating the kills of out of state hunters and then recalculating the waterfowl correlations the following results were obtained:

	r	z
Ducks	.979	2.28
Geese	.981	2.32

The increase in the duck correlation is so slight as to be practically meaningless, but the goose correlation is raised over $2\sigma_d$ above its former value and is roughly on a level with the duck figure.

The low jack rabbit correlation is probably due partly to the lack of care with which these animals are recorded on the license application blanks, and partly to a comparatively few ranchers and professional rabbit trappers who killed really large numbers of these animals. Doubtless, these men were not adequately sampled by the mailed questionnaire and this may have helped reduce the correlation.

In summary, it may be said that the agreement between the mailed questionnaires and the license applications is very close. We should obtain satisfactory county by county records from mailed questionnaires, especially if in the future we increase the number sent to the smaller counties and include a sample of out of State hunters.

[4] Oregon hunters also do some waterfowl hunting in Siskiyou County, but adding their kills to the mailed questionnaire total for that county would have been a slight over-correction.

PROGRESS REPORT ON THE CENTRAL VALLEY FISHERIES INVESTIGATIONS, 1939[1]

By S. Ross Hatton

Bureau of Marine Fisheries

California Division of Fish and Game

INTRODUCTION

Since the first gold miners of the past century began diverting water from the natural channels of the streams entering the Central Valley of California, conditions detrimental to fish life in those streams have increased at an alarming rate. The demands of navigation, salinity control, irrigation, flood control and hydro-electric developments have all resulted in the pyramiding of conditions which are continually making aquiculture of less importance in this region.

From the first small, unscreened irrigation diversion of the early settler, irrigation projects have increased to a point where the complete flow of streams has been diverted during the irrigation season and impounded during the balance of the year. Likewise, hydro-electric plants have completely blocked many of our streams to the natural movements of migratory fish, and have created an environment throughout the balance of the streams that is unsuited to the natural propagation of several fish species.

The growth of cities along the stream edges, with the resulting pollution of the waters by industrial wastes, likewise has caused a decrease in the fish fauna of the streams.

These conditions have been growing in number and diversity since settlers first entered the Central Valley. Each individual dam or diversion was seemingly of no importance, and only recently has the public realized that the cumulative effect of these structures has reduced the fish populations of many streams to an alarming level.

The construction of the initial units in the Central Valley Project is of such magnitude that considerable interest has arisen as to the future status of the commercial and sport fishery in waters of the Sacramento-San Joaquin River system. Past events make this concern wholly justifiable, as witnessed by the decline in the salmon fishery of the Sacramento River. In 1880, ten million pounds of salmon were taken by commercial fishermen in the lower Sacramento River. This is in contrast to an average annual catch of less than one million pounds for the five-year period, 1934-1938. Various factors have

[1] Submitted for publication, June, 1940. The author is indebted to Mr. G. H. Clark of the Bureau of Marine Fisheries, California Division of Fish and Game, for aiding in the planning and directing of all phases of this investigation, and also for valuable assistance in preparing this report. The investigation of the fisheries affected by the Central Valley Project was instigated at his suggestion and has been carried on under his direction. Also, thanks are due to the following employees of the Division for their aid in gathering the data presented in the report: Messrs. C. B. Alleman, Herman Mix, H. L. Lantis, B. L. Farschon, Henry Frahm, Hilton Burgstrom, William Stewart and Albert Frush.

contributed to this decline; primarily, overfishing and the destruction of natural spawning areas by dams and diversions. Clark (1929) estimated that by 1928, 80 per cent of the salmon spawning beds of the Sacramento-San Joaquin River system had been thus destroyed. Of the remaining salmon spawning areas, an estimated 40 per cent of the available beds in the Sacramento River will be destroyed (Hanson, Smith and Needham, 1940, p. 47) and Friant Dam will make 11 per cent of the salmon spawning areas of the San Joaquin River system inaccessible.

The Central Valley Project has been long advocated and its necessity recognized by engineers and economists. As early as 1873, an investigation was made by the United States War Department and a plan submitted for utilizing the water supply to the greatest advantage.

In 1878 the State investigated the problem, which resulted in "An act to provide a system of irrigation, promote rapid drainage and improve navigation on the Sacramento and San Joaquin rivers." Under this act, several reports and maps were published between 1880 and 1888.

From 1888 to 1921 the water problem of the Central Valley was investigated by several State and Federal agencies. In 1921 a series of State investigations known as "The California Water Resources Investigations" was undertaken, which resulted in the formulation of the State Water Plan. This Plan included the Central Valley Water Plan.

The Central Valley Project, embodying the proposals of the Central Valley Water Plan, was undertaken by the United States Bureau of Reclamation. Actual construction of Shasta Dam, the primary unit of the plan, was begun in the spring of 1938. Construction of other main units is now under way and progressing toward completion in 1943.

The anticipated benefits to be accrued after the completion of the Project are of such magnitude that the average individual has given no heed to the future welfare of the aquatic biota of the streams to be affected. And, in the great majority of cases, those directly responsible for the instigation and completion of the Plan had given no previous consideration to the future of the fisheries in the streams of the Central Valley. It was only after bids had been received for the construction of Shasta Dam that biological surveys were undertaken to study the effect of the dam on the salmon runs passing the dam site. These surveys are being made possible by grants from the United States Bureau of Reclamation, and are under the supervision of the United States Fish and Wildlife Service (formerly the United States Bureau of Fisheries). The activities of this agency have been restricted to a study of possible salmon salvage methods in the Sacramento River and its tributaries. The results of this investigation have been published (Hanson, Smith and Needham, 1940).

In January, 1939, the California Division of Fish and Game undertook a survey of the San Joaquin River system and the Sacramento-San Joaquin Delta. The primary purpose of this investigation is to determine the effect of the Central Valley Project upon the fishes of that area, and to suggest, where advisable, remedial measures. Actual

field work started in March, 1939, and the results of the first season's survey are included in the following report. Time does not allow an investigation as comprehensive as the importance of the plan justifies. Only those phases which gave promise of immediate and practical application can be considered because of the short time before completion of the Central Valley Project.

This investigation is concerned with the formulation of practical conservation measures which might be employed to maintain the fish population in an environment changed by the water project now under construction. In a broad sense, the ecological associations of the important species in this area must be determined; the effect of diversions, dams, changed water levels, salinity control, and changed temperatures anticipated; and then legal measures recommended and mechanical aids undertaken to protect, as much as possible, the fish populations of the river systems.

A chief concern in the investigation is the three important anadromous species of the area: salmon (*Oncorhynchus tschawytscha*), striped bass (*Roccus saxitalis*), and shad (*Alosa sapidissima*). Incidental to the study of these species, information is also being obtained on the resident species inhabiting the area. Among them are the split-tail (*Pogonichthys macrolepidotus*), Sacramento pike or squawfish (*Ptychocheilus grandis*), fork-tail catfish (*Ameiurus catus*), square-tail catfish (*Ameiurus nebulosus*), small-mouthed black bass (*Micropterus dolomieu*), and large-mouthed black bass (*Micropterus salmoides*), in addition to some species of lesser importance, such as the Sacramento perch (*Archoplites interruptus*), bluegill (*Lepomis macrochirus*), and crappie (*Pomoxis annularis*).

THE WATER PLAN OF THE CENTRAL VALLEY PROJECT AND ITS EFFECT ON FISH LIFE

The scope of the Central Valley Water Project of California and the profound changes in factors affecting the fish life of that area can be realized by studying the outline of the plan of development as shown in figure 126.

Shasta Dam, just above Redding, is the first project of the Central Valley's development. This dam, now in construction, will be over 500 feet high and will flood into the Pit River, Squaw Creek, McCloud and Little Sacramento rivers, thus eliminating the salmon spawning grounds above the dam. A concurrent construction project is the Contra Costa Canal, which starts at Rock Slough in the Delta region near Knightsen, and runs through Contra Costa County back of the town of Antioch. The water in this canal will be used for irrigation and industrial and domestic water supply.

A third project of the plan is the Friant Dam, located on the San Joaquin River just above Friant. This dam, now in construction, will block the river for diversion of water south to Bakersfield and north into the Madera Canal. Friant Dam will not only destroy the salmon runs above the site, but also from present indications there will be insufficient water released from the dam, so that the runs frequenting the spawning areas below Friant will be destroyed.

The other immediate projects of the Central Valley's development will not be started until the Shasta and Friant dams are near comple-

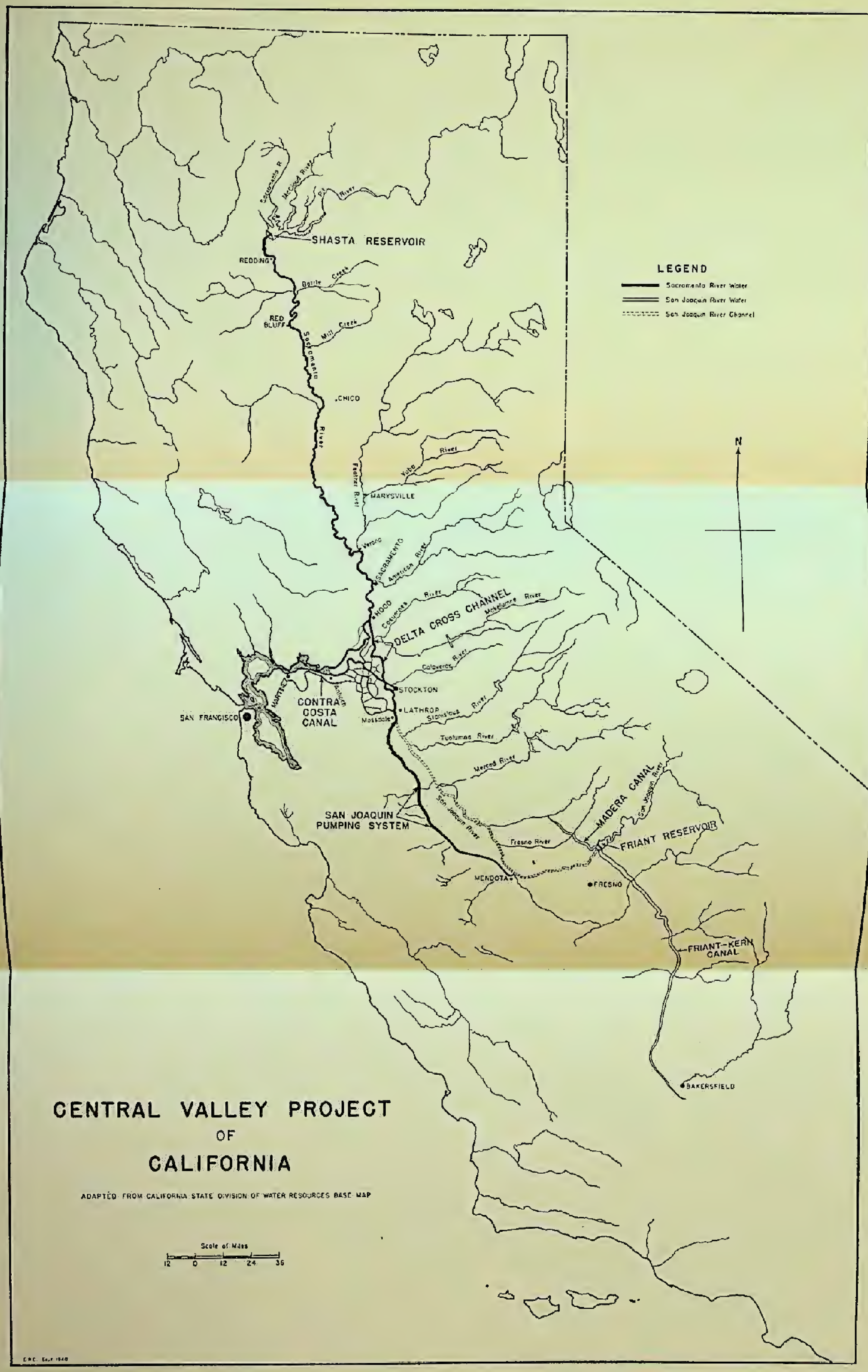

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Fig. 126.

tion. Thus, the construction of the take-off canal or pump at Hood on the Sacramento River (to supply extra Sacramento River water to the San Joaquin system for irrigation) and the high line canal to Mendota will not be started until the major units, Shasta and Friant dams, are near completion. If a direct take-off is made from the Sacramento River, it will necessitate a low dam, about twelve feet in height, across the main Sacramento River near Hood. If a dam is erected, there must be a lock for navigation, and in addition at least one fish ladder provided in the structure. If the take-off is by pump over the levee, it will be necessary to screen adequately against small fish entering the pump. Regardless of the type of take-off, the water will be shunted down through the Delta region in a closed canal system to the San Joaquin River near Stockton, then through a canal on the west side of the valley to Mendota on the San Joaquin River. According to present plans, the San Joaquin River channel will be used from a point near Stockton to Lathrop as a part of the pumping system. The water in this section of the river bed will then flow backward while the pumps are in operation. This section will also act as a collecting system for drainage waters of the San Joaquin system to be pumped back through the high line canal during months of heavy water use for irrigation at Mendota Dam.

To prevent small downstream migrants, as well as resident fishes, which may find their way into this stream of water for the high line canal, from entering the canal and pumps, it will be necessary to screen this canal at a location just up the river from Stockton. Screening will also be necessary in the San Joaquin River north of Lathrop, as well as the construction of a by-pass for the return of young migrants and the formation of a passage for adult fishes to ascend the San Joaquin River.

An important feature of the water plan provides for control of saline invasion into the Delta region. At present it is planned to release sufficient water from the Shasta Reservoir to check at a point near Antioch the encroachment of water carrying over one part of chlorine in a thousand parts of water. This will provide a year-around supply of fresh water for the multitudinous irrigation pumps and siphons in the Delta region and also for the Contra Costa canal. This feature of the plan will decrease considerably the present extent of the brackish water nursery grounds for striped bass and shad but will increase the area of those waters populated by the fresh-water species.

SCOPE OF FISHERIES INVESTIGATIONS

The fisheries investigations, as conducted by the California Division of Fish and Game from March, 1939 to June, 1940, have been concerned with the obviously important and urgent phases. One main object has been to determine the dates and sizes at which the progeny of the anadromous species undertake their seaward migration. In this respect it has also been deemed advisable to determine other factors in connection with the downstream movement, such as differential preference for stream sections and size distribution in these areas. Aside from mechanical difficulties, the installation of adequate screening facilities will depend upon an understanding of the seaward migration.

A knowledge of present spawning areas and those which may be available after the completion of the water project is also necessary. This item is of particular importance in the case of the salmon. It is likewise essential to define in a general way at least the spawning and nursery grounds of shad and striped bass. Correlation of the present shad and striped bass spawning areas with various external factors such as salinity, temperature and flows is also important.

General studies of the food of shad and striped bass have been undertaken to a limited extent.

Aside from biological factors, data are being collected on possible improvements and locations for installation of fishways and screens, in the hope that the loss of waters suitable for fish life after the completion of the engineering project may be somewhat compensated for by improving the conditions affecting the survival of the remaining fish.

As the study proceeds, it is anticipated that additions and deletions to this preliminary outline will be necessary.

INVESTIGATIVE METHODS EMPLOYED

Actual field work began in March, 1939 with the establishment of stations at Martinez, Hood and Mossdale. (See Fig. 126.) Martinez is located on the Carquinez Straits of the Sacramento River about 32 miles from the Golden Gate. The river at this point is about one mile wide and has a channel depth of around 80 feet. This site was selected because of the narrowness of the river at this point. It is below the junction of the Sacramento and San Joaquin rivers so that an investigator has the advantage of being able to intercept the movements of those species which do not ascend the river to either of the other stations. It is also a concentration locale for commercial and sport fishermen, which offers the advantage of obtaining additional observations and specimens which may aid in the investigation. Except for the winter months, the water of the Carquinez Straits is brackish, at times as much as sixteen parts of chlorine per thousand. River traffic at this point often interfered with investigational netting operations, and not infrequently the water was too rough to carry on the work.

Hood is also on the Sacramento River, about 85 miles from the Golden Gate. (See Fig. 127.) The river at this point is about 500 feet wide and has a channel depth of 30 feet. Both sides of the river have precipitous, sloping levees. Hood is situated above all the numerous sloughs which traverse the Delta region and connect the Sacramento and San Joaquin rivers, so that any fish intercepted at this point are residents or migrants of the Sacramento River. This station is well within the tidal basin, but is above the point of saline invasion.

Mossdale is located on the San Joaquin River, about 110 miles from the Golden Gate. At this point, the river is normally 300 feet wide and of very variable depth. Levees extend along both banks of the river, but near Mossdale they are some distance away from the

FIG. 127. The Sacramento River at Hood. Photograph by author.

usual stream edges. This site is above the line of saline invasion and is near the limit of the tidal basin. As is the case at Hood, Mossdale is above the region of the Delta sloughs, so any specimens obtained at this point are migrants or residents of the San Joaquin River system. The three stations selected are roughly at the apexes of a triangle, one on each corner of the Delta region.

The stations at Hood and Martinez have been continuously maintained from March, 1939 to May 1, 1940. The station at Mossdale was abandoned as a permanent site after the downstream salmon migration had passed in 1939, but was reestablished in February, 1940. However, in the intervening time, netting was carried on irregularly at Mossdale.

Fyke nets were used for taking immature downstream migrants. These nets are 16 feet long, with a 5-foot circular opening tapering to 3 feet. One-half inch stretched mesh was as small as could be used because of floating debris and water resistance, although this size undoubtedly permitted the escape of numerous fish. At times when the current was exceptionally strong it was necessary to use a net with an opening of 3 feet in diameter, tapering to 2 feet. Results obtained with the small nets have been weighted so as to be comparable with the more frequently used large nets. The nets were fished either from a skiff or an anchored buoy or when possible from dolphins and piers. (See Fig. 128.)

In addition to fyke nets, drift gill nets of various sizes (up to nine inches, stretched mesh) were used to ascertain the presence of larger fish. Some larval fish and fish eggs were taken with a metal plankton net, having 64 openings to the square inch.

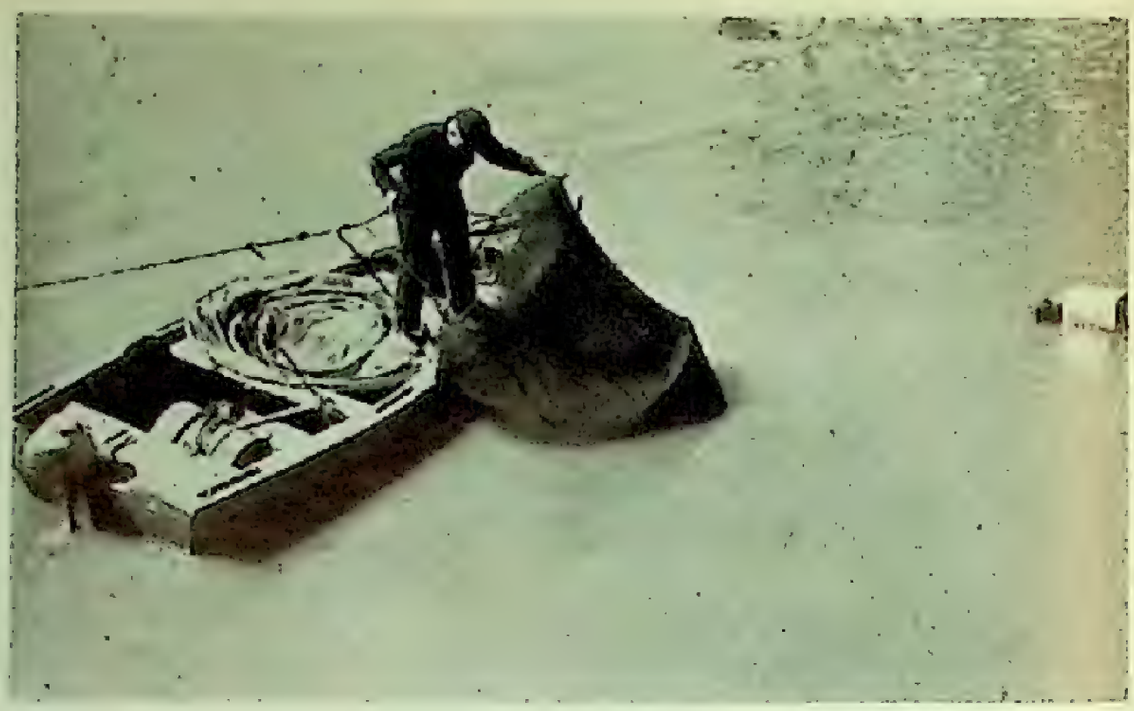

FIG. 128. Hauling in a fyke net on the San Joaquin River. Photograph by author.

The salmon spawning areas of the streams of the San Joaquin system were determined by the following method.[2]

The linear length of the spawning grounds of each stream was divided into sections, each section one-tenth of a mile long. The length of each section was determined by pacing (and recording on a hand tally) 100 double steps, or approximately 528 feet. One person did the pacing and tallying, while another recorded the percentage of stream area covered by pool and riffle in each section. By the same procedure the percentage of spawning area in the stream could be determined directly from the tally. In arriving at a percentage to express the amount of spawning area, it is necessary to determine if the sizes of gravel and rate of flow are favorable for salmon spawning. Broadly speaking, areas with gravel from pea to baseball size, with sand and fine gravel among the interstices, covered by a depth of five inches of water flowing two to three miles an hour, were considered to be suitable for salmon spawning. In most cases we were aided in determining suitable spawning conditions by the presence of nesting salmon. Each stream was visited when salmon were on the grounds, and so our estimates of spawning grounds are based upon the type of bed in which nests were actually made. At the completion of each section, each investigator estimated the percentage of spawning area for that section. When the estimates were in close agreement an average was taken, otherwise the section was surveyed again to obtain a percentage agreeable to both persons. As often as necessary the width of the stream at the water level was meas-

[2] The method here described is that developed in the State of Washington in connection with salmon surveys of the Columbia River. The same method is being used in the survey of the salmon spawning grounds of the upper Sacramento tributaries by the U. S. Fish and Wildlife Service. We are indebted to Mr. Harry A. Hanson, of the U. S. Bureau of Reclamation, for instructions concerning this phase of the work and for the field experience we gained from him and the members of his party.

ured by tape where suitable crossings were encountered, or by optical distance meters when the width was not too great. At other times it was necessary simply to estimate the width, which could be done quite accurately after some practice.

Each stream was surveyed from its mouth to the first impassable barrier, which, with the exception of a natural barrier on the Cosumnes, is a hydro-electric plant and the attendant dam. Generally, there is a mile or more between the power plant and dam, but this portion of the stream has not been surveyed for obvious reasons. The lowest of these dams is 83 feet in height and consequently is considered as impassable to fish by means of a fish ladder. There are several obstructions on the Merced River and one on the Stanislaus which at present block the passage of salmon. They are of such a nature, however, that they can be made passable; consequently, the areas above these dams have been surveyed.

The system of surveying available spawning areas made these areas easily expressible in any desired unit, such as square feet, as used in this investigation. To determine the carrying capacity of any given stream, or stream section, we allowed 40 square feet of suitable area for each redd or nest.[3] This number is to be considered as empirical only and may of necessity be changed in the future as additional data are accumulated.

A difference in the water flow in any one of the streams will materially affect the available spawning area. It was found impractical, however, to make even reasonably accurate observations on spawning grounds projected to higher stream levels. Therefore, the results represent the spawning area available at the stream level existing when the survey was made, which places the measurements on the conservative side, as 1939 was an unusually dry year. (See Appendix A.)

Proceeding southerly, the tributaries of the San Joaquin are: Cosumnes River (a tributary of the Mokelumne River), Mokelumne River, Calaveras, Stanislaus, Tuolumne and Merced. With the exception of the Calaveras, all these streams now support a salmon run.

MIGRATION OF YOUNG SALMON

Hood Station

The preservation of the Sacramento River salmon runs to a degree where commercial exploitation is possible, demands among other things, adequate protection to the downstream emigrants. The diversion of a maximum of 8000 second feet of water from the Sacramento drainage into the San Joaquin system introduces an acute problem in protecting the salmon fry from being carried up the latter stream. Following their inherent tendency to go with the current will prove fatal to those fry which are diverted by a dam or pump lift from the Sacramento into the San Joaquin pumping system. The presence of fry in the Sacramento during those months when this water diversion will occur, necessitates the considera-

[3] This estimate is based upon measurements obtained by the Shasta survey party of the U. S. Fish and Wildlife Service, and we used the same procedure in order that their results and ours might be comparable.

tion of adequate screens at the point of take-off or before the water enters the series of pumps beginning near Stockton. The location of the screens will depend upon whether the diversion is made by a dam or by pumps; and if pumps are used, upon the type of pump and their location in the stream. In the event that immature salmon can be safely taken into the Delta Cross Channel, the screening can take place where the first of the pump series is encountered in the canal. However, in a closed canal system provision must be made by means of by-passes to allow the fish to escape through any one of several natural sloughs and to again enter the Sacramento River.

Regardless of the method of diverting water into the Delta Canal or the ultimate location of the screens, the need of greater knowledge concerning the time and duration of migration, sizes of migrants, and place in the stream where the majority of migrants occur is apparent.

A forty-year period has elapsed since any systematic attention has been given the downstream salmon migrants in the Sacramento system. In January, 1899, netting operations for immature salmon were undertaken at the head of Georgiana Slough for investigative purposes, and were continued to May of the same year (Rutter, 1903). Georgiana Slough takes off the Sacramento River at Walnut Grove, some 12 miles below Hood. The gear used by Rutter consisted of a 4-foot circular bag to which 20-foot wings were attached; one wing was fastened to the shore, and the other was anchored in midstream. The presence of wings unfortunately makes it impossible to compare some of the items in his results with those obtained during the present investigation, because of the difference in gear used; however, the results show a surprising similarity.

TABLE 1

Number and Average Hourly Catch of Young Salmon Taken Daily at Hood, 1939

Date	Number of fish	Average catch per hour	Date	Number of fish	Average catch per hour
March 6	3	0.50	April 7	81	7.04
7	10	1.25	8	61	4.27
12	19	3.17	10	33	7.71
13	59	4.00	11	49	5.25
14	28	1.90	12	49	4.90
15	20	2.77	13	31	3.38
16	372	57.23	14	40	4.22
17	425	67.20	15	38	5.07
18	63	18.00	16	68	3.57
20	49	19.60	17	125	4.03
21	78	9.75	18	115	3.15
22	57	9.34	19	80	4.10
23	310	50.36	20	26	2.60
24	365	52.14	21	26	2.60
25	148	49.33	24	26	3.50
27	236	34.86	25	19	2.33
28	159	21.20	26	1	0.07
29	1	1.33	27	19	0.86
30	103	12.48	28	15	0.67
31	134	20.46	29	7	0.45
April 1	111	26.12	May 3	1	.....
3	36	12.00	4	4	.....
4	109	15.20	5	1	.....
5	141	11.52	9	3	.....
6	62	4.97			

TABLE 1—Continued
Average Total Length and Standard Deviation of Each Weekly Sample

Date	Average size in mm.	Standard deviation	Number of fish
March 5-11	40.00	*4.85	13
March 12-18	39.36	2.87	136
March 19-25	38.54	3.26	105
March 26-April 1	38.81	3.87	104
April 2-8	39.87	2.46	85
April 9-15	40.76	1.05	09
April 16-22	42.65	4.18	102
April 23-29	42.10	3.01	50
April 30-May 8	53.14		

* Statistical measure corrected for small sample.

The downstream migration of 1939 was well under way when actual field work was begun at Hood on March 6, 1939, and continued to May 9, 1939. The average number of salmon taken per hour each day, the weekly average total length, and also the standard deviation of each weekly sample are given in table 1. During the period covered in 1939, it was apparent that the majority of the migrants passed Hood during March. The greatest peak occurred on March 16 and 17, when on the latter date an average hourly catch of 67.20 salmon was taken; the next highest peak occurred March 23, with an hourly average of 56.36 fish. It is interesting to note that the greatest number taken by Rutter in 1899 during any one day was on March 20, with a slightly lesser peak occurring on March 8. Although a direct comparison between the fishing effort of the gear used by Rutter and that used in this investigation is not possible, it is indicative that the average catch per hour of Rutter's gear on the peak day was 29.5 fish and on the next highest peak it was 28.5 fish. Rutter does not definitely state that the net was fished continuously; however, N. B. Scofield[4] states that the net was pulled in three times daily to remove the fish, and otherwise the gear was in operation both day and night. Hence, the averages given for Rutter's gear are substantially correct. Disregarding the presence of wings, the fyke nets used in the present investigations should be 20 per cent more efficient because of the larger size, but this is an inadequate explanation of the difference in the catch of the two nets.

The number of spring migrants decreased rather sharply from the first of April in the 1939 data until the first of May, when only a few individuals were taken. The last fish taken by Rutter was May 8, and the last of the 1939 spring migration was taken at Hood on May 9. Table 2 gives the number and percentage of fish taken each month during the 1899 and 1939 investigations. Here again, the data are not comparable, but they unmistakably show that the majority of the migrants passed down the lower Sacramento River in March of 1899 and 1939. During normal years, water probably will not be taken from the Sacramento River into the Delta Cross Channel until April or May, which will allow most of the migrating salmon to proceed safely downstream past the take-off at Hood. Likewise, establishing the time of the downstream migration in the lower

[4] N. B. Scofield, recently retired Chief of the Bureau of Marine Fisheries, Division of Fish and Game of California, was engaged in the salmon investigation with Rutter in 1899, and did the work at Walnut Grove.

reaches of the river systems indicates that the loss of salmon fry in existing unscreened pumps and diversions is of less importance than previously supposed.

TABLE 2

Number and Percentage of the Total Number of Salmon Fry Taken During Each Month of the Downstream Migration at Walnut Grove in 1899 and at Hood in 1939

	Walnut Grove, 1899		Hood, 1939	
	Number of fry	Percentage	Number of fry	Percentage
January	169	3.26	.....	.....
February	118	2.28	.....	.....
March	4,507	87.00	2,750	66.50
April	365	7.05	1,376	33.30
May	24	0.46	9	0.20
Totals	5,183	.....	4,135	.....

For ease in comparing lengths and distribution of samples, Rutter's measurements have been converted to millimeters, and the averages presented in weekly groupings in table 3. Collating this with the statistics obtained at Hood in 1939, a noticeable difference in average size becomes apparent. It may be judged from the standard deviations that Rutter's last several samples included a few individuals comparable in size to the larger fish taken at Hood in 1939, but this overlap in sizes is less than 5 per cent of the total individuals measured. This would indicate that Rutter's last few weekly samples were from a population that may no longer be encountered in the Sacramento River.

It is entirely logical to assume that this difference in size may be best explained by the subsequent cutting off of the upper salmon spawning grounds throughout the Sacramento drainage basin. The known tendency for salmon to spawn increasingly earlier with an increase in latitude or altitude infers that our present seaward migrants are smaller in size than those previously encountered because they were spawned later in the season and traveled a

TABLE 3

Average Total Length and Standard Deviation of Salmon Fry Taken at Walnut Grove by Rutter in 1899

Date	Average length in mm.	Standard deviation	Number of fish
January 20-28, 1899	39.62	2.51	55
January 29-February 4	41.14	3.48	28
February 5-11	45.46	*2.36	9
February 12-18	45.72	*3.37	23
February 19-25	50.03	*4.02	19
February 26-March 4	45.21	5.70	168
March 5-11	44.70	3.53	122
March 12-18	42.67	*2.05	21
March 19-25	43.43	*2.46	23
March 26-April 1	46.22	*6.60	22
April 2-8	50.29	7.13	109
April 9-15	54.35	7.72	135
April 16-22	64.51	9.04	69
April 23-29	72.90	12.06	33
April 30-May 8	70.86	11.83	29

* Statistical measures corrected for small sample.

shorter distance before reaching the ocean. From the same supposition, it is probable that the proportion of salmon migrating near the end of their first year in the stream has decreased as the more distant spawning grounds have become inaccessible. Specifically may be mentioned the series of dams on the Pit River, built between 1922 and 1927. Likewise, the West Branch, North Fork and South Fork of the Feather River were blocked to salmon after about 1914, and this description may be continued to include practically all the streams tributary to the Sacramento.

Although the results of only seven nights of fishing are available, there is an indication of a nocturnal migration exceeding that of the diurnal from the present investigation. In five cases of the seven, the movement was greater at night than during either the preceding or succeeding day, and in one of the other cases, the night movement was greater than that of the succeeding day. As the flood waters recede and the water becomes clear, it is possible that more of the migrants move at night. Rutter detected no difference in intensity between a diurnal and nocturnal migration.

Results at the Hood station in 1939 indicate that the migrating fry are rather sharply restricted to certain portions of the stream. This area may be tentatively placed at from shore to 70 feet off shore and in the upper 8 feet of water, with a greater concentration between 40 and 50 feet off shore. Some difficulty was experienced in making net sets nearer than 7 feet from the shore; only on occasion was the current strong enough to properly fish the nets, and anchoring them into position proved perilous because of the underlying riprap and an assorted accumulation of debris.

For several days during April, 1939, one net was anchored on the bottom, and a second net buoyed above it, so it was possible to fish the upper 6 feet of water as well as the bottom 5 feet. The depth at that place was about 14 feet, leaving an approximate distance of 3 feet between the nets. During a comparable number of hours, 8 salmon were taken in the bottom net and 158 in the upper net; but of course we had no way of knowing that the 8 fish were not taken while the net was being raised or lowered into position. Similar results were obtained by seining at distances beyond 60 or 70 feet from shore. Forty-nine hours of fishing at a distance of 70 feet off shore to mid-stream resulted in no catch at all. There is apparently no difference in the number of migrants on either bank. Rutter (1903) states that in 1899 the same number of fish was taken regardless of the position of the net.[5] The difference in the size of the main Sacramento and Georgiana Slough may explain this difference in results of the 1899 and 1939 investigations.

Mossdale Station

Field work at Mossdale began on March 13, 1939 and continued until the end of the salmon migration during the last of May, after which the nets were intermittently used about one day each week. In comparison with Hood, surprisingly few salmon were taken at

[5] Scofield informs me that from his notes of observations in fishing this fyke net in 1899 that only once was the net used in mid-stream; the rest of the time one wing was attached to the bank.

Mossdale. During March, 1939, 91 times as many fish were taken at Hood as at Mossdale; during April, seven times as many; but during May, nine times as many were taken at Mossdale as at Hood.

One peak of migrants appeared on May 3, 1939 (see Table 4), with an hourly average catch of 4.18 salmon during an eleven-hour period. On the preceding day no fish were taken, and on May 4 the catch dropped to an average of 0.41. Later inquiries determined that on May 3, an irrigation weir several miles upstream had been removed for a few hours, and the resulting head of water may have been responsible for the large catch. The water gauge at Vernalis on that date registered a flow of 3100 second feet, whereas on the preceding day the reading was 2600 second feet, and the following day 2460 second feet. Using two nets these fish were all taken between midnight and five in the morning; after that the catch average dropped to the usual figure.

TABLE 4

Number and Average Hourly Number of Salmon Fry Taken at Mossdale, 1939

Date	Number of fish	Average catch per hour	Date	Number of fish	Average catch per hour
March 13	0		April 15	1	0.30
14	7	1.00	17	28	3.20
15	8	0.98	18	40	2.31
16	3	0.42	19	14	0.80
17	0		20	11	0.60
18	0		21	8	0.48
20	3	0.36	22	5	0.59
21	2	0.37	24	5	0.28
22	0		25	0	
23	0		26	2	0.11
24	1	0.13	27	1	0.05
25	0		28	1	0.09
27	0		May 1	6	0.20
28	0		2	0	
29	1	0.11	3	46	4.18
30	5	0.62	4	6	0.41
31	0		5	8	0.42
April 1	17	1.42	6	3	0.46
3	10	1.39	8	2	0.28
4	17	1.42	9	3	0.17
5	4	0.55	11	1	0.06
6	7	0.98	12	2	0.11
7	5	0.60	13	0	
8	2	0.57	15	2	0.13
10	3	0.25	16	5	0.29
11	3	0.31	17	0	
12	2	0.20	18	2	0.11
13	7	0.77	19	1	0.05
14	2	0.25			

Average Total Length and Standard Deviation of Each Weekly Sample

Date	Average size in mm.	Standard deviation	Number of fish
March 12-18	40.05	*4.01	18
March 19-25	47.00	*6.80	6
March 26-April 1	54.96	*6.58	23
April 2- 8	56.32	9.26	45
April 9-15	62.67	*6.08	18
April 16-22	63.23	7.14	106
April 23-29	66.55	*6.94	9
April 30-May 6	69.73	5.36	69
May 7-13	69.38	*5.17	8
May 14-20	73.90	*9.20	10

* Statistical measures corrected for small sample.

The next highest peak of migrants was on April 17 and 18, 1939, which probably represents the normal height of the downstream migration for the period during the survey. Another peak occurred on April 1 to 4, with an average only slightly less than on April 17 and 18.

Migrants were taken until the middle of May, 1939, at a date somewhat later than at Hood. Of the total number of migrants, 9.6 per cent were taken during March, 62.5 per cent during April, and the remaining 27.9 per cent during May. The average catch of salmon per hour for the three months was as follows: March, 0.26; April, 0.77; and May, 0.33.

Evidence indicates that most of the migrants at Mossdale descend near the middle of the channel, just the reverse of the situation at Hood. Fishing two nets simultaneously, one about 45 feet off shore in 4 feet of water and the other about 95 feet off shore in 6 feet of water, the latter net took more fish on 17 days out of the 20 days during the time this experiment was conducted. The difference between Hood and Mossdale in the migration of young salmon in relation to the depth and distance from shore may be due to the difference in the declivity of the banks or to the size of the migrants.

No data are available to show that the migrants prefer the surface or lower levels of the San Joaquin River at Mossdale. In places where the depth was greater than about eight feet, there was generally insufficient current to fish the nets properly. In the experiment mentioned above, however, the results may be interpreted as showing a preference for the depth encountered in mid-channel, rather than the position from the shore line. However, the generally shallow depth range at the section of the stream at Mossdale, where the experiment was conducted, lends credence to the assumption that the distance from shore rather than the depth determined the section of the stream in which most of the seaward migrants were encountered.

At present it is impossible to state if there is any difference in the number of migrants moving during the day or night at the Mossdale station.

The weekly average total length of salmon taken at Mossdale and also the standard deviation are given in table 4. This shows a marked contrast to the Hood samples, in that the fish are much larger at Mossdale for corresponding weekly periods, and also the increase in size between the first and last weekly samples is much greater than at Hood. The majority of the migrants passed Mossdale during April, or one month later than at Hood.

A comparison between the sizes of fish taken in the two nets previously mentioned shows that the larger individuals are taken near the middle of the stream. There is a difference of 4.78 mm. in the average of the two size groups, which is of decided statistical significance.

Verona Station

Through cooperation with the United States Fish and Wildlife Service, we were able to trap downstream salmon migrants at Verona for the two-week period between April 6 and 21, 1939. Verona lies at

the junction of the Feather and Sacramento rivers, hence it was possible to net fish in both streams. Most significant of the results obtained at Verona was the almost complete absence of salmon migrants in the Sacramento River. (See Table 5.) During the period covered (April 6 to 21, 1939) the peak of the migration in the Feather was on April 13; and from April 6 to 15, nearly twice as many fish per hour of fishing effort were taken as between April 17 and 21. During 78 hours of fishing on the Sacramento River, only two salmon were caught; these, however, were two of the largest specimens taken.

TABLE 5

Summary of Salmon Taken Daily in Fyke Nets at Verona, 1939*

Date	Number of fish	Average catch per hour	Average length, mm.**	Standard deviation	Weighted total***	Weighted average catch per hour
April 6	7	3.11			7	3.11
11	19	2.23			47	5.5
12	24	3.26	39.27	2.03	60	7.8
13	28	4.14			70	10.04
14	20	2.07			50	5.18
15	14	1.78			35	4.47
17	4	1.06			10	2.67
18	4	0.46			10	1.15
19	1	1.72	41.00	3.69	3	5.18
20	8	2.66			20	6.66
21	4	0.80			10	2.00
Totals	133				322	

* The data in the above table are from netting operations on the Feather River. Seventy-eight hours of seining on the Sacramento River at Verona resulted in two salmon of 42 and 49 mm.

** Average length in millimeters calculated on weekly basis.

*** Numbers weighted to correspond to size of net used at other stations. Because of current velocity, it was necessary to use a smaller net at Verona.

Martinez Station

The first seaward migrant salmon at Martinez were taken on March 23, about two weeks after netting operations commenced at that station. From then until the middle of July specimens were taken in varying amounts, but in view of the small numbers the run may be said to have ceased at the end of May. A peak occurred on March 27 and 28, and one again on April 7; the former with an average of 16 fish per hour, and the latter with nearly 7 per hour. The peak run on March 27-28 may correspond to the one passing Hood on March 17, and the one on April 7 may correspond to the Hood peak of March 23. In the first case, it is indicated that the passage required 10 days, and for the Hood peak of March 23 to reach Martinez required 14 days. Rutter (1903) estimated that a week was required for salmon to make the distance between Walnut Grove and Benicia. The actual time required for the passage may vary by several days and be dependent upon such factors as the tidal phase and the discharge from the two rivers.

We have no conclusive data as to which part of the stream at Martinez carried the greater number of migrating fry. Fish were taken within several feet from shore but were usually caught at an estimated 700 feet from shore, and one specimen was taken in the middle of the stream. Water traffic and commercial fishing activities confined our experimental fishing range somewhat.

The weekly average total length, average number of fish taken per hour, and the standard deviation of the weekly samples of salmon fry taken at Martinez in 1939 are given in table 6. For the first three weeks of operation, the sizes closely approximated those at Hood. From the middle of April, the average length increased markedly and likewise the standard deviation. It can be assumed that this increase in size is due to the advent of the San Joaquin fish, as the size of the few specimens taken from May to the end of the spring migration indicates that the sample was predominantly from the San Joaquin River.

TABLE 6

Daily Summary of Salmon Taken in Fyke Nets at Martinez, 1939

Date	Number of fish	Average catch per hour	Date	Number of fish	Average catch per hour
March 23	2	0.3	April 15	0	
24	5	1.05	17	6	0.92
25	3	0.6	18	0	
27	34	17.0	19	7	0.48
28	108	16.0	20	4	2.00
29	13	3.0	21	3	0.55
30	24	7.7	22	1	0.25
31	51	7.1	24	0	
April 1	0		26	4	0.80
3	1	0.66	27	0	
4	2	2.00	28	3	0.67
5	3	0.66	29	0	
6	1	0.21	30	2	1.00
7	83	6.64	May 8	6	
8	7	2.33	9	4	
10	7	0.63	15	1	
11	30	4.28	16	1	
12	0		26	1	
13	9	0.66	June 20	2	
14	0		July 13	1	

Average Total Length and Standard Deviation of Each Weekly Sample of Salmon Fry

Date	Average size in mm.	Standard deviation	Number of fish
March 26-April 1	39.46	3.10	195
April 2- 8	41.05	5.10	95
April 9-15	48.00	7.28	52
April 16-22	49.52	*6.24	21
April 30-May 6	74.39	7.55	62

* Statistical measure corrected for small sample.

There is ample evidence to indicate that in addition to the spring migration in the Sacramento-San Joaquin system, there is also a summer or fall migration of immature salmon consisting of larger fish but fewer individuals. The investigations of Rutter (1903) indicated such a summer or fall run, and likewise the studies made by Rich (1920). During the greater part of the summer and fall, salmon may usually be seen in the upper Sacramento River and its tributaries, the majority of them of a larger size than those taken during the spring in the lower reaches of the river. It is likewise known from Clark's (1929) study that about 20 per cent of the Sacramento salmon migrate during the succeeding fall, when their size is about 100 mm. From this group of fall migrants, we have taken at the most one or two specimens, although netting at Hood and Martinez was continued

during the summer and fall. Rutter in 1899 likewise was unable to obtain any salmon after June. One 85-mm. salmon taken at Martinez on July 13 could possibly be from the fall run. Another specimen, 101 mm. long, taken at Martinez on May 4, 1939, may have been a holdover from the preceding year. It appears that it would be advisable to employ a different type of gear for taking these larger specimens.

SEAWARD MIGRATION OF IMMATURE STRIPED BASS

Hood Station

The first young striped bass were taken at Hood on August 3, 1939, and from then until the end of October they were intermittently taken in the fyke nets but never in any great amount. They were most numerous during the week of August 20 to 26, and again from October 8 to 21. The sizes of the first bass taken and also the quantity rather definitely indicate that there is no regular downstream movement of small bass at Hood, at least not comparable to the migration as it occurs at Martinez. In fact, bass of the sizes taken at Hood could easily have ascended to that point, rather than have been descending the stream when intercepted. Table 7 gives the number of bass taken weekly at Hood in 1939 and also the average total length of each sample.

TABLE 7

Number and Average Length of Striped Bass of the Year Taken Weekly at Hood, 1939

Date	Number of fish	Average length, mm.
July 31-August 5	1	53.00
August 6-12	0	
August 13-19	5	54.60
August 20-26	24	60.26
August 27-September 2	0	
September 3- 9	2	61.00
September 10-16	3	62.66
September 17-23	4	66.50
September 24-30	1	65.00
October 1- 7	5	92.00
October 8-14	23	87.01
October 15-21	23	87.69
October 22-28	10	88.40

Mossdale Station

Daily netting was discontinued at Mossdale before any bass of the year were taken. Consequently, our records for this phase of the investigation are not as complete as desirable.

Weekly sampling throughout most of the summer resulted in very few bass being taken. The first specimen, measuring 38 mm. in total length, was obtained on June 26. The next bass were taken on July 21 and were 41 and 52 mm. in total length. Specimens were occasionally taken throughout the summer and fall. The last ones were taken on January 19, 1940 and were 80 and 86 mm., total length. In addition to the Mossdale specimens, two fish, 31 and 34 mm., total length, were taken in the Mokelumne River, seven miles above its mouth, on June 26. Bass fry about 40 mm. long were observed during June in several places in the upper Delta region

mainly in the Disappointment, Sycamore, Hog and Beaver sloughs, and at several places in the South Fork of the Mokelumne.

From the fish rescue reports of the State Division of Fish and Game, it must be inferred that bass fry are much more numerous in the vicinity of Mossdale than our reports indicate. A few rescue records selected at random are interesting. On October 7, 1936, 191 bass, about two inches in length, were taken from a small canal near Tracy; and on December 21, 1935, 866 bass of the same approximate size were rescued at the same locality. Frequent rescues of bass of the year have been made in the lower Cosumnes River and in canals south of Lodi, generally during October, November and December. From these and observational reports, it seems that small bass are fairly common throughout the upper Delta region during the latter part of each year, and if a definite seaward migration occurs it may be as late as December or January for some individuals.

TABLE 8

The Average Total Length, Standard Deviation, and Average Hourly Catch of Each Weekly Sample of Striped Bass Taken at Martinez from the Time of the First Appearance of the 1939 Brood to April 27, 1940*

Date	Average total length, mm.	Standard deviation	Average hourly catch
June 11-17, 1939	28.04	3.15 (171)	
June 18-24	27.11	3.53 (386)	
June 25-July 1	33.75	---- (4)	
July 2- 8	37.84	5.50 (25)	3.9
July 9-15	37.66	---- (6)	
July 16-22	41.47	12.27 (38)	1.7
July 23-29	46.64	15.61 (28)	0.63
July 30-August 5	51.44	5.82 (707)	57.3
August 6-12	60.72	10.28 (107)	37.3
August 13-19	63.09	9.91 (51)	25.0
August 20-26	65.90	10.70 (185)	21.0
August 27-September 2	62.58	15.21 (153)	21.0
September 3- 9	72.06	10.93 (102)	12.0
September 10-16	77.96	9.72 (96)	11.0
September 17-23	83.56	8.44 (33)	13.0
September 24-30	89.30	14.07 (211)	14.0
October 1- 7	89.26	11.28 (181)	5.5
October 8-14	94.58	11.63 (26)	3.5
October 15-21	92.22	13.63 (36)	3.4
October 22-28	100.08	13.44**(17)	
October 29-November 4	100.37	---- (8)	2.0
November 5-11	101.74	12.92 (56)	1.8
November 12-18	102.18	12.34 (76)	1.7
November 19-25	100.02	10.59**(15)	0.50
November 26-December 2	113.10	---- (10)	0.50
December 3- 9	104.28	10.72 (38)	0.97
December 10-16	104.25	---- (4)	0.44
December 17-23	101.72	14.97**(18)	0.43
December 24-30	113.60	14.13**(19)	0.42
December 31-January 6, 1940	105.00	16.87**(16)	0.54
January 7-13, 1940	106.50	21.38**(16)	0.23
January 14-20	104.00	---- (1)	0.02
January 21-27	95.94	12.71**(18)	0.24
January 28-February 3	95.28	14.97 (36)	0.33
February 4-10	91.48	13.61 (83)	0.78
February 11-17	92.90	15.71**(17)	0.18
February 18-24	96.46	15.02 (33)	0.39
February 25-March 2	90.32	12.14 (39)	0.27
March 3- 9	98.80	15.79 (26)	0.22
March 10-16	97.16	14.85 (36)	0.17
March 17-23	95.94	16.66**(24)	0.17
March 24-30	76.74	12.59**(24)	0.19
March 31-April 6	98.00	---- (12)	0.13
April 7-13	98.08	15.58 (17)	0.14
April 14-20	92.46	14.07**(19)	0.18
April 21-27	95.74	10.31 (25)	0.30

* The number of specimens used in calculating the average and standard deviation is given in parentheses.
** Statistical correction for small sample.

Martinez Station

In sharp contrast to Hood and Mossdale, large numbers of small bass have been taken at Martinez, and consistently enough to indicate a definite migration. The first fish were taken on June 14, 1939, their average total length being 26 mm. The peak of the movement at Martinez occurred from July 30 to August 12, and a smaller peak during the week of June 18 to 24. The catch per hour has gradually declined since July, 1939, as shown in table 8, which gives the average catch per hour, the average total length and the standard deviation; each statistic based on a weekly sample.

During July young bass may be commonly seen in Carquinez Straits, congregated in schools, and unless frightened or disturbed they always stem the tide. They seem to seek sheltered spots behind piles and dolphins and in the lee of boats. During this time of the year, they are especially numerous in tidal creeks and basins. As the season advances they are no longer seen near the surface but are still most numerous in the upper ten feet of water. They may be collected with fyke nets on either tide, and even reversing the gear on the same tide makes no appreciable difference in the number caught. However, more fish are generally taken on the ebb tide than on the flood.

At Martinez, several thousand bass were marked by excising fins and many of these marked fish have been recaptured at the same place. In many cases there was an almost complete regeneration of the fins which had been removed for marking purposes, where the cut was not made sufficiently close to the body. In other cases the scars were well healed, which indicates that individual bass may remain for some time in one locality before proceeding seaward or to the more open waters of lower San Francisco Bay. The results of our first season's work on the striped bass in this locality indicate that some bass remain in Carquinez Straits until they are at least a year old.

SEAWARD MIGRATION OF IMMATURE SHAD

Hood Station

Shad of the year were first taken at Hood on June 23, 1939 and were taken thereafter to the end of October. The greatest number migrated during the week of August 20 to 26, with a lesser concentration of numbers on July 2 to 8. The weekly average catch per hour for the high point of the migration was 4.8 fish.

Unfortunately, no record was kept of the size of the first migrants, but the largest and smallest specimens of the first group observed were 20 and 15 mm., respectively. Subsequently, the size irregularly increased until a high average of 95 mm. was reached toward the end of September. (See Table 9.)

During the last of August and the first of September, young shad may usually be seen breaking surface during the evening hours, often in such large numbers as to give the impression that the surface is being sprayed with buckshot. It was possible to verify the presence of shad at Hood by this characteristic jumping habit for at least two weeks after they had ceased being taken by fyke nets.

TABLE 9

Number and Average Total Length of Shad Taken Weekly at Hood, 1939

Date	Number of fish	Average length, mm.
June 18-24	16	
June 25-July 1	0	
July 2- 8	52	27.3
July 9-15	30	43.1
July 16-22	17	51.75
July 23-29	5	49.2
July 30-August 5	4	44.5
August 6-12	0	
August 13-19	14	77.64
August 20-26	63	75.57
August 27-September 2	5	69.40
September 3- 9	2	71.00
September 10-16	17	89.23
September 17-23	4	95.75
September 24-30	0	
October 1- 7	10	78.90
October 8-14	44	87.88
October 15-21	20	87.15
October 22-28	9	79.66
October 29-November 4	2	80.00
December 10-16	1	95.00

Mossdale Station

As is the case with striped bass at Mossdale, little information is available on shad movements at the Mossdale station. One 28-mm. specimen was taken on May 30. Small fish, presumably shad, were seen jumping on several occasions during the summer but they successfully evaded the nets.

Martinez Station

Shad were taken at Martinez over a month earlier than at Hood. (See Table 10.) The first specimens were taken on April 21, and the next on May 4, 1939. The latter date is assumed to mark the beginning of the regular seaward migration past Martinez. From then on, shad were taken rather constantly until near the end of June. From

TABLE 10

Number and Average Total Length of Shad Taken Weekly at Martinez, 1939

Date	Number of fish	Average length, mm.
April 16-22	2	46.5
April 30-May 6	275	38.75
May 7-13	82	33.00
May 14-20	21	35.05
May 21-27	81	33.97
May 28-June 3	2	39.5
June 11-17	24	40.87
June 18-24	50	41.01
July 23-29	1	90.0
August 6-12	3	87.33
August 13-19	11	91.54
August 20-26	1	93.0
August 27-September 2	9	96.33
September 24-30	1	110.
October 1-7	1	109.
November 5-11	1	102.
December 24-30	2	117.
December 31-January 6, 1940	1	135.
January 14-20, 1940	4	114.

July until February, samples have been taken only occasionally. The peak of the shad migration occurred during the week of April 30 to May 6, with an hourly average catch of 5.8 fish for the week. For days of this week on which fish were taken, the average catch was much higher; for instance, on May 5, it was 11.5 fish per hour for a 13-hour period. Practically all the shad were taken on the ebb tide during May and June, but during other months of the year they can be taken on any tide.

MIGRATION OF ADULT SHAD

With the possible exception of shad, no new information, other than that already published, is available on migration of adult fish through the Delta region. It is generally assumed that the opening of the commercial shad season on February 15 marks the beginning of the shad spawning migration. Even though some shad are taken at this time, it is usually about one month later that they appear in any numbers at Martinez. The height of the 1939 migration at Martinez occurred shortly after the close of the commercial season on May 15. Thereafter, shad were taken in decreasing amounts until the end of June.

Shad first appeared at Hood about the middle of April, 1939 and were fairly numerous during the first part of May. The greatest number of migrants appeared from May 23 to June 6, after which the numbers gradually decreased. The last fish during this migration were taken during the first few days of August.

Proceeding upstream, the first shad, in any noticeable numbers, reached the Butte-Sutter Dam on the Feather River on May 26, 1939. In the Sacramento River the fish had ascended as far as Redding by June. Shad appear to be numerous in the upper Sacramento during the first of June, and are most abundant around June 10.

SALMON SPAWNING AREAS

One of the greatest changes to be anticipated as a result of the Central Valley Water Project is the destruction of spawning areas for salmon. The diversion of water will make some of the present spawning areas inaccessible to fish by the construction of dams, as at Friant and Shasta, or by the complete drying of river channels below dams where no permanent spillways are provided. Or, certain ecological factors, an optimum combination of which may be essential to the spawning act, can be materially changed. The program for salinity control may seriously restrict the present available spawning areas for several species, by altering such physical factors as salinity, stream flow and temperatures. On the other hand, the possibility exists that a partial stabilization of some of these factors may be beneficial.

When, however, spawning areas are cut off by dams, the decrease in available areas is directly measurable; hence, the necessity of determining the available spawning areas above and below any proposed dams is practical in the case of the salmon. Where the possibility of transferring any part of a spawning population to another available area exists, it is also expedient to determine the amount of spawning

areas in any stream which might carry an increased number of spawners.

Cosumnes River

The spawning grounds of the Cosumnes River extend from the Sloughhouse Bridge to a natural barrier one-half mile below the Latrobe Highway Bridge, a distance of 15.2 miles. The stream varies in width from 30 to 50 feet. The most favorable areas are between the Sloughhouse and Bridgehouse bridges; a short distance above Bridgehouse the stream enters a canyon and the gravel beds are replaced to a large extent by bedrock. Of the total linear length of the river in which spawning beds occur, an average of 3.51 per cent of the distance is available for spawning. Expressed in square feet, this represents an area of 117,263 square feet, or a total spawning capacity of 2,932 female salmon. As this figure is based upon the number of nests the stream will actually support, it must be doubled to include the number of salmon the stream will support, or 5864 fish. Hereafter in this report the number so expressed will include both male and female salmon.

During the months that water is diverted from the Bridgehouse Dam for irrigation, the lower end of the stream is dry, but during late fall a run of undetermined size takes place. In 1939 the fish were first observed on the spawning grounds on December 11; a few fish, however, were in the stream by December 1.

The only permanent dam on the stream is the Bridgehouse Dam constructed in 1921. This dam is 18 feet high and has two apparently satisfactory fishways. The take-off diversion is unscreened.

Mokelumne River

Spawning beds on the Mokelumne River extend from the Lockford Bridge to the Pardee Dam, a distance of 22.5 miles. As is typical of all the Central Valley salmon streams, the gravel beds are most numerous in the foothills, and then decrease markedly as the streams enter the canyons. (See Fig. 129.) Of this 22.5-mile section, 3.79 per cent consists of available spawning beds, which is equivalent to an area of 381,411 square feet. Using our empirical minimum of 40 square feet per nest, this stream has a carrying capacity of 19,070 salmon.

An irrigation dam at Woodbridge on the Mokelumne is provided with a fishway but due to fluctuating water levels it is at times impassable. (See Fig. 132.) It is probable that the bulk of the migrants do not ascend to the spawning beds until the weir boards are removed from the dam, which is generally around the first week in November.

The 1939 fall run started on November 8.

Stanislaus River

The spawning beds of the Stanislaus River extend from the Riverbank Bridge to the Malone Power House, a distance of 32.7 miles. Of this distance, 9.3 miles of stream between Goodwin Dam and the Power House are only rarely accessible to salmon. Although there is a fishway over Goodwin Dam it is seldom passable. The fluctuating water level above Goodwin Dam and the almost complete diversion of water at the dam make it very nearly an impassable barrier. This change

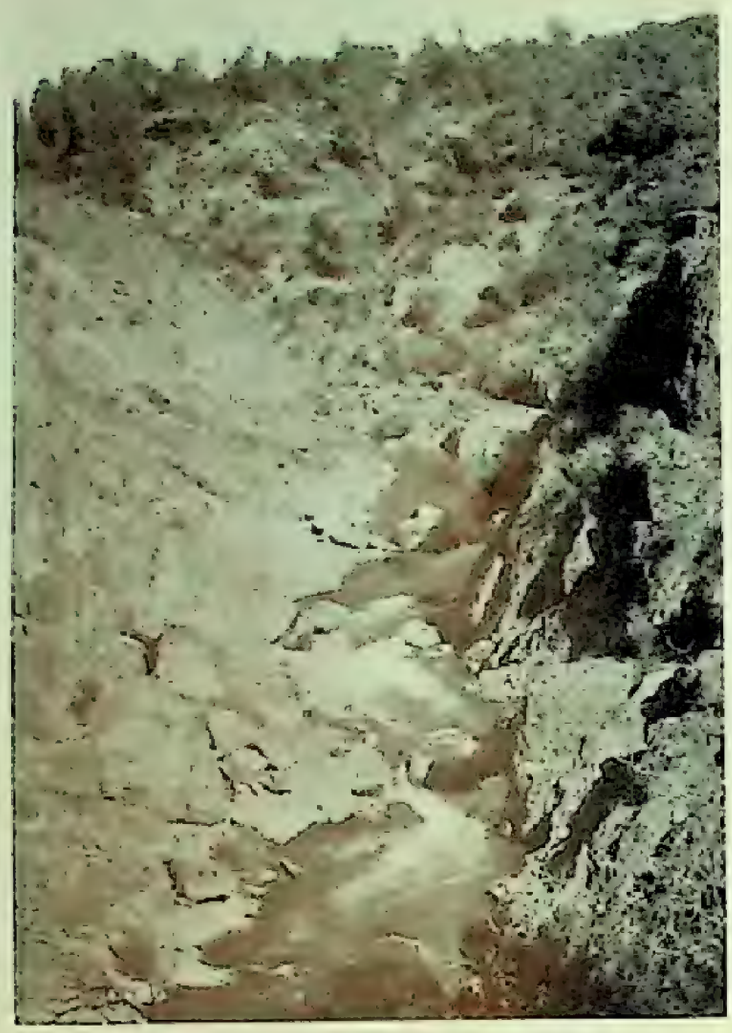

FIG. 129. The Mokelumne River, just below the Pardee Dam. This section is typical of the streams of the San Joaquin system before they emerge upon the gravel slopes below the canyons. Photograph by C. B. Alleman.

in water level, due to irregular operations of the hydroelectric plant, seriously impairs salmon propagation in the stream as a whole. Of the total 144,686 square feet of spawning area, only 17,787 square feet are above Goodwin Dam. The entire stream has a total spawning capacity of 7,234 fish, 888 of which would be required to spawn above the dam if the stream carried its maximum run. Expressed in percentages, 2.74 per cent of the stream bed is suitable for spawning, and of the total available spawning area only 12.4 is above Goodwin Dam.

Tuolumne River

The spawning beds of the Tuolumne River extend from a point 2.2 miles below the railroad bridge at Waterford to the La Grange Power House, a linear distance of 23.5 miles. Of this distance, an average of 1.78 per cent is available for spawning, or 193,806 square feet. This represents a total spawning capacity of 9,690 fish based on 40 square feet per redd.

Indications are that the Tuolumne River more nearly approaches its spawning capacity than any of the other streams surveyed. The 1939 fall run apparently began about the first of October, and by the middle of the month many fish were nesting. (See Fig. 130.)

The Tuolumne River is fortunately clear of obstructions until the impassable La Grange Dam is reached. The Modesto Weir is a low structure from which the flash boards are removed several weeks in advance of the fall run. This weir provides water for recreational purposes and has no diversion.

FIG. 130. Salmon nesting on the Tuolumne River, one and a half miles below La Grange, November, 1939. The gravel piles in the background, the result of gold dredging operations, are familiar sights along many of California's salmon streams. Photograph by B. L. Farschon.

Merced River

Suitable spawning areas on the Merced River are encountered from a point half a mile downstream from a line run due south of Balico, to the Exchequer Dam, a linear distance of 42.4 miles. Of this distance, only an average of 0.52 per cent is suitable for spawning. The total square feet of spawning area is 57,993, or the equivalent of a total spawning capacity of 2,900 fish. (See Fig. 131.)

Actually only 24.1 miles of the available spawning area in the Merced River are accessible to salmon under present conditions. There are on this stream eight low rock dams and four beaver dams. Under usual water conditions the beaver dams are passable, but the rock dams are not. In no case are the rock dams provided with a fishway, and they are left in position the entire year. The only water below each rock dam is seepage, and even where suitable gravel beds exist between dams, there is either insufficient water for spawning or insufficient flow due to impounded water above the next dam. The Merced Falls Dam, located above the rock dams, is provided with a fishway, which of course

is inaccessible to salmon because of obstructions lower in the river and lack of sufficient water flow.

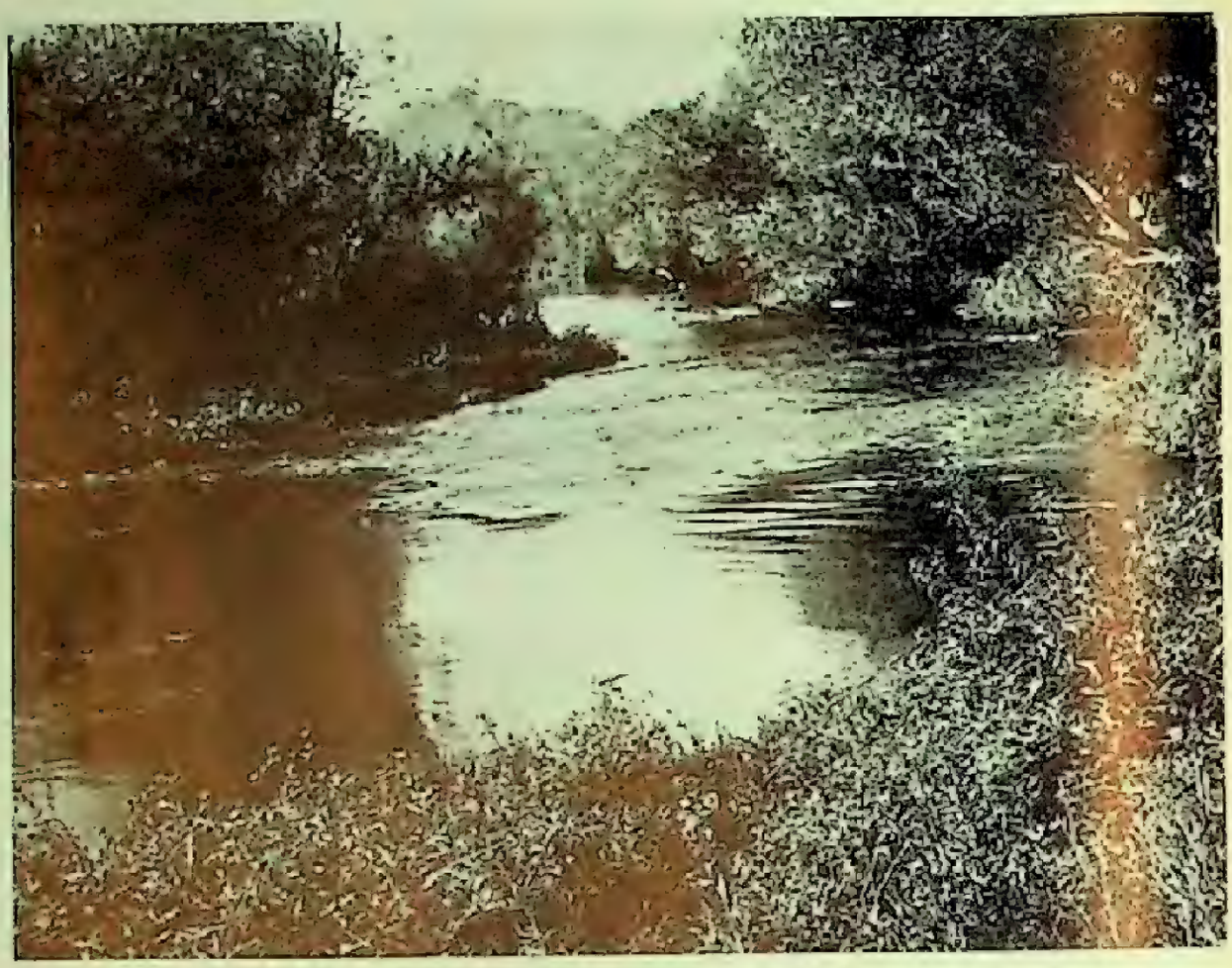

Fig. 131. A typical salmon spawning riffle on the Merced River. Photograph by author.

Adequate water release from the Exchequer Dam would double the present spawning capacity of the Merced River by making the installation of fishways practical in the rock dams. Under conditions existing at the time of the survey, however, only 1.07 per cent of the total *available* spawning area is above the first barrier.

The 1939 fall run began about the middle of October.

San Joaquin River

From our standard of comparison, the upper San Joaquin River has the most suitable spawning beds of any stream in the San Joaquin system. The stream is much wider than any of the other streams; the gravel is of notable uniform size; and there is a favorable succession of pools and long riffles. Even during the dry year of 1939, most of the suitable areas were adequately covered with water and the water level was satisfactorily constant. Above Friant, however, where the stream enters the canyon, bed rock predominates, and the long, deep pools are connected by short stretches of turbulent water.

The San Joaquin River is accessible as far as the Kerckhoff Power House, and the salmon spawning grounds extend from there down to Lane's Bridge, a distance of 26 miles. The best and most frequently used areas are between Lane's Bridge and Friant. The average per-

centage of the total area available for spawning is 2.08, with a total spawning capacity of 20,738 fish.

The Friant Dam, located about one mile above Friant, will cut off 16 miles of the stream in which spawning now occurs. Although this represents over half of the linear stream distance, only 35.7 per cent or 148,315 square feet of the salmon spawning beds will thus be destroyed. The spawning capacity of the stream above Friant Dam is 7,416 salmon. The spawning beds below Friant Dam are at present so underpopulated that even after the completion of the dam more than adequate areas will still be available, if water flows are adequate.

Actually, destruction of the spawning areas above the Friant Dam will thus not create any salvage problem. The problem arises in diverting the water from the beds below the dam. However, it is hoped that seepage from the dam and returned irrigation water will provide sufficient flow to make spawning possible. Until more definite information is available as to the water flow past Friant Dam, a salvage problem will have to be considered.

The San Joaquin River, in the area where spawning occurs, is singularly free of obstructions and diversions. Proceeding upstream the first obstruction encountered, before the spawning grounds are reached, is the sack dam of the Poso Irrigation District, several miles below Firebaugh. In the average water year this dam destroys any possibility of a fall run of salmon up the San Joaquin. The complete diversion of water at the dam leaves the stream bed practically dry between that point and the mouth of the Merced River. The sand bags of the dam are left in place until they are washed out by the winter floods. The only other obstruction on the San Joaquin below the spawning grounds is the Mendota Weir at Mendota. This weir is equipped with a satisfactory fishway. The eight diversions above the dam, all unscreened, constitute a serious menace to the downstream migrants. Immature salmon were taken in all these canals during April and May of 1939, in addition to resident spiny-rayed fishes.

In some years a fall run has been able to reach the spawning beds by making a hazardous and circuitous journey through a series of natural sloughs and irrigation laterals, beginning near the mouth of the Merced and miraculously entering the river through the main canal above Mendota Weir.

The 1939 spring run in the San Joaquin River was from April 12 to about May 20.

SHAD SPAWNING AREAS

Although the shad spawning areas of the Sacramento-San Joaquin River systems and the Delta have heretofore received no special study, the general assumption that shad spawn throughout the Delta region is only partially correct. Observations made during the 1939 spawning season point to the centralization of spawning activities in the upper Delta region, near the limit of the tidal basin, and only in fresh water. In addition to the upper Delta region, a large part of the spawning population utilizes the streams flowing into the Delta, some ascending these streams for considerable distances.

Within the Delta region the spawning activity has been observed in several places, and undoubtedly takes place generally above brackish water, but apparently increasing in intensity as the tidal limits are reached. On the Sacramento River, spawning fish were observed and taken in the vicinity of Hood and were very abundant at Portuguese Bend, eleven miles above Hood. A convenient way of taking specimens at this place during the spawning peak was merely to row a skiff rather close to shore and pick up the fish which were struck with an oar. Proceeding upstream, many spawning shad were observed at Ord's Ferry and Sid's Landing—approximately opposite Chico and about a hundred miles from Sacramento. Although direct observations are lacking, it is very probable that spawning takes place throughout the length of the Sacramento River below Red Bluff, where suitable stretches of quiet water are found. Harry Hanson reports that shad ascend the fishway at Redding during the spawning time, so a limited amount of spawning may even occur above Red Bluff.

Shad also spawn in the Feather River, at least as far up as the Sutter-Butte Dam, and some are known to ascend the fishway over this dam. In the pool below the dam intense spawning takes place. A four-minute drift with a gill net (50 feet long) at this place on May 29, 1939, yielded 17 specimens, from the majority of which the sexual products flowed freely. In the rather quiet water near Gridley, a short distance below the dam, was a dense congregation of spawning fish. On the Yuba River, a tributary of the Feather River, shad migrate as far as the Daguerre Point Dam and may be assumed to spawn in this river. Evidence of spawning on the American River was reported by Merrill Brown, in charge of the State's fish rescue program, who took several thousand shad fry, approximately one inch in length, at Fair Oaks, on August 8, 1939.

Observations during the 1939 season indicate that the San Joaquin River is not as extensively or as intensively used as a spawning place for shad as is the Sacramento. However, rather heavy spawning was noted in Old River. On several occasions eggs were taken at Mossdale, indicating that spawning is higher up. One plankton net haul made at McCloud's Beach, about eight miles above Mossdale, indicated that eggs are comparatively numerous there. One female, with running eggs, taken at the mouth of the Stanislaus, is our only indication of spawning occurring any distance up the San Joaquin River.

Evidences of Shad Spawning

Spawning shad may be generally detected by their erratic surging and plunging, which accompanies the extrusion of the sexual products. To fishermen of the eastern coast, this act is known as "washing," and on a quiet evening these sounds may be distinctly heard from the river banks. The direction of movement during spawning is from the channel toward the shore. Wherever possible we have collected "washing" shad to note the condition of the sexual products, in order to verify the assumption that "washing" accompanies the spawning act. In such cases running females were commonly taken and less frequently ripe males. It is assumed that the size of mesh used in our nets allowed most of the smaller males to escape.

In addition to "washing" and the presence of fish from which the roe and milt were freely flowing, in some instances we have taken fertilized shad eggs in plankton nets. The eggs were taken by placing a plankton net on the bottom of the stream and anchoring it in position for several hours. Occasional samples were taken during the day, but the eggs were much more numerous at night, particularly from midnight to dawn. The eggs may have been deposited at a point some distance upstream from where the collections were made, but the distance could not have been great, judging from the state of development of the eggs.[6]

STRIPED BASS SPAWNING AREAS

After an unsuccessful attempt in 1907 and 1908 by the California Board of Fish and Game Commissioners to locate bass spawning areas in the Sacramento and San Joaquin River system, and unsuccessful attempts in 1929 by E. C. Scofield (1931), investigator for the California Division of Fish and Game, the subject has since then been given only theoretical consideration. During 1907 and 1908, it was attempted to propagate this species artificially, and a hatchery building was constructed on Bouldin Island for this purpose. The proposal was to obtain ripe males and females from the commercial fishermen operating in the vicinity. Only the males were obtainable in numbers, however. Several females, apparently ripe, were so secured but during the second season a report (Scofield and Coleman, 1910) concluded that "The taking of a female bass with ripe eggs was evidently a lucky chance, and we have not been able to locate their spawning place." On May 28, 1908, one unmistakably ripe female was obtained in Disappointment Slough, and from this one striped bass 227,000 fry were reared and later liberated.

A third attempt, made during this present investigation, to locate bass spawning areas has likewise been unsuccessful. Rather than attempt to net spawning fish, our efforts were directed toward obtaining eggs and larvae in plankton hauls. A plankton net was frequently used at Hood, Mossdale and elsewhere throughout the Delta as occasion permitted. Striped bass larvae[7] were taken on June 8, 1939, in False River and Washington Cut. The specimens ranged in size from 6 to 23 mm., but were most abundant at from 6 to 10 mm., total length. Judging from the studies and records of Scofield and Coleman (1910) and Pearson (1938), the 6-mm. specimens are from eggs fertilized seven or eight days previously, which places the area in which these eggs were spawned some distance above the point of capture. Two other bass larvae, 11 and 13 mm. long, were taken in Sycamore Slough on June 23, 1939. This seems to indicate that the spawning areas are located near or above the upper Delta limits. However, this assumption differs in some degree with the results obtained from investigating the downstream movement of small bass, as previously discussed (page 350).

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[6] The author is indebted to Mr. John C. Pearson, in charge of the shad investigations for the U. S. Fish and Wildlife Service on the eastern coast, for identification of the shad eggs we collected.

[7] The author is indebted to Dr. A. W. C. Herre, of Stanford University, for identifying the larval specimens.

FEEDING HABITS OF STRIPED BASS AND SHAD

Food of Adult Striped Bass

Since the introduction of striped bass into the Sacramento River there has been a growing assumption that bass annually destroy numerous salmon fry. The known predacious habits of the bass would naturally lead to this analogy, and in spite of the lack of positive evidence the literature shows an increasing number of references to this assumption. This belief has become more prevalent since the work of Shapovalov (1936) on the food of striped bass in the Waddell Creek Lagoon, where salmon and trout fry were found in 14.8 per cent of the bass stomachs examined. Shapovalov also reports the occurrence of small salmon and trout in bass stomachs from Coos Bay, Oregon.

Numerous studies of the food of the bass from the Sacramento River have been made (Scofield, 1928.1, 1928.2, 1931; Scofield and Bryant, 1926) and in no instance have salmon fry been encountered in any of the stomachs. Scofield (1931) states that the serious depletion of salmon in the Sacramento is the probable reason that none has been found in bass stomachs. Other stomach samples have been collected at a time when no small salmon were in the river. It is, likewise, generally believed that bait-caught fish do not accurately reveal the feeding habits of the fish. Therefore, in spite of ample general information about the food habits of bass, the incidence of seaward migrating salmon in their diet has been generally assumed.

As a part of a general ecological investigation of migrating young salmon, it seemed desirable to determine to what extent, if any, young salmon are eaten by striped bass. Accordingly, a net-caught sample of 224 adult bass was obtained at a time in which it was known that young salmon were in the locality in which the collection was made. The bass were taken in shad drift gill nets near Pittsburg, between March 13 and May 4, 1939. These dates coincide with the time of the downstream salmon migration as determined by netting operations at Martinez, some 18 miles downstream from Pittsburg. The first salmon of the year were taken at Martinez on March 23, and the run continued until the end of May. The peak of the run was during the last of March, at which time young salmon were as abundant as any of the species taken in the fyke nets. There can be no question then that seaward migrating salmon were available to the bass which were taken in the sample for stomach analysis, and also that the salmon were sufficiently numerous to make it illogical to assume that they were not eaten because of scarcity.

In view of the existing information about the food habits of striped bass no attempt was made to specifically identify all the organisms encountered. (See Table 11.) In such cases where fish were present, whose size did not preclude the possibility of their being salmon, the identification was carried sufficiently far to remove any doubt. In many cases, the process of digestion had proceeded to a point where specific identification was impossible.

TABLE 11

Analysis of Stomach Contents of Adult Striped Bass, Taken near Pittsburg, March 13 to May 4, 1939

Number of stomachs examined	224
Percentage of empty stomachs	56.6 per cent
In March sample	55.8 per cent
In April sample	50.0 per cent
In May sample	68.3 per cent
Percentage of all stomachs in which fish or remains of fish were present	34.0 per cent
Striped bass or remains of bass present	2.67 per cent
Identifiable clupeoids present	4.01 per cent
Identifiable osmerids present	4.90 per cent
Identifiable split-tails present	3.57 per cent
Identifiable lampreys present	0.89 per cent
Identifiable atherinids present	0.40 per cent
Identifiable catfish or sculpins present	1.34 per cent
Unidentifiable fish or remains of fish present	18.74 per cent
Percentage of stomachs in which Crustacea or remains of Crustacea were present	11.22 per cent
Shrimp or shrimp remains present	11.2 per cent
Crabs or remains of crab present	1.78 per cent
Percentage of stomachs in which unrecognizable digested material was present	3.57 per cent
Percentage of stomachs in which plant material (tules) was present	2.23 per cent

Miscellaneous items: Two stomachs contained fertilized egg masses—probably carp spawn.

As in previous stomach series taken for food studies of this species, the number of empty stomachs encountered is surprisingly large. The assumption has been that with hook and line only the hungrier individuals would be caught, which explains the large number of empty stomachs in the specimens taken by this method. The same condition, however, exists in the net-caught sample reported here, where over 50 per cent of the stomachs examined were empty. It is noteworthy that a greater portion of the fish taken in May had empty stomachs than in either of the two preceding months.

In addition to the fish taken near Pittsburg, two small stomach samples were taken. On April 24, 1939, five bass were taken in the Yuba River at Marysville, and with the exception of sardine bait, their stomachs were empty. A sample of nine hook-and-line-caught fish, taken April 19, 1939, from Potato Slough, were likewise empty of natural food.

The results of this investigation seem conclusive that salmonoid fry form no important part of the food of striped bass in the lower Sacramento River. It cannot be maintained, however, that young salmon are never eaten by bass, but the number of fry so destroyed must surely be negligible.

Although analysis of the stomach contents of Sacramento pike taken at Hood in the spring of 1939 revealed young salmon, no other cases of species predatory upon young salmon have been observed in the lower Sacramento River.

At Mendota Weir on the San Joaquin River, young salmon were found in the stomachs of three spiny-rayed fishes out of four taken on May 13, 1939. Very frequently, at this location, black bass and crappies were observed eating salmon fry, but we were unable to obtain a larger series of stomach contents to determine the extent of this predation.

Food of Immature Striped Bass

With an anticipated restriction of the encroachment of saline waters in the Delta region, it becomes expedient to determine if possible

what effect this will have on the extent of the feeding grounds for small bass throughout the Delta region. In view of this change, studies of the general feeding habits of small bass in fresh and brackish waters were started.

The first series of stomachs from small bass were taken at Martinez during September and November, 1939, and consisted of 76 specimens. (See Table 12.) These fish, ranging in size from 27 to 157 mm., were from the spawning of the previous spring and are presumed to have been migrating to the ocean or lower San Francisco Bay when taken.

TABLE 12

Analysis of Stomach Contents of Yearling Striped Bass Taken at Martinez, September and November, 1939

Number of stomachs examined	76
Percentage of empty stomachs	25.3 per cent
Percentage of all stomachs containing fish or fish remains	10.6 per cent
Percentage of all stomachs containing crustaceans or crustacean remains	69.4 per cent
Isopods (*Synidotea laticauda*) present	32.0 per cent
Amphipods present	40.0 per cent
Shrimps (*Crago*) present	5.3 per cent
Crab remains present	1.3 per cent

With the advent of floods in the Central Valley drainage basin, beginning in January of 1940, the waters at Martinez became fresh, causing a noticeable change in the fish fauna present, as well as in the diet of the small striped bass. The amphipods and isopods, which formed their main dietary species when brackish water was present, disappeared almost completely. This occasioned no evident change in the abundance nor size composition of the small bass taken in the fyke nets.

A sample of 58 stomachs, taken during February and March, from bass of the previous spring's spawning, were found to be feeding almost exclusively on a species of Mysidacea (*Neomysis mercedis*). (See Table 13.)

Preliminary observations show that no appreciable change in abundance of striped bass is to be anticipated as a result of restricted saline invasion into the Delta region. The one controlling factor in the dietary habits of small striped bass appears to be simply availability. In practically all food studies of small bass, however, one or several forms of Crustacea constitute the bulk of their diet.

TABLE 13

Analysis of Stomach Contents of Yearling Striped Bass Taken at Martinez, February and March, 1940

Number of stomachs examined	58
Percentage of empty stomachs	10.34
Percentage of stomachs containing unrecognizable digested materials	12.03
Percentage of stomachs containing mysids (*Neomysis mercedis*)	77.62

Food of Shad

Studies of the food of adult shad on their spawning migration were undertaken in order to determine their general feeding habits while in the area to be affected by the Water Project. The very successful introduction of shad into California waters from the Atlantic Coast pre-

supposes an abundance of suitable food organisms throughout the area of their range.

Several comprehensive studies of the food of adult shad (Leim, 1924; Leidy, 1868; Brice, 1897; and others) have been made in Eastern rivers where little or no food is found in the stomachs of migrating shad in fresh water. Smith (1896) reported a similar condition for the shad of the Pacific Coast.

The food studies made during this investigation are based upon a collection of 141 stomachs, made at Pittsburg during the first two weeks of May, 1939. They were obtained from the commercial fishermen operating in the vicinity. The results of this analysis are presented in Table 14.

TABLE 14

Analysis of Stomach Contents of Adult Shad Taken at Pittsburg, May, 1939

Number of stomachs examined	141
Percentage of empty stomachs	22.7
Percentage of stomachs containing *Neomysis mercedis*	60.0
Percentage of stomachs containing copepods	37.5
Percentage of stomachs and intestines empty	2.1
Percentage of individuals with material in intestines*	53.0

* The material here noted had the appearance of a greenish, or less frequently, a reddish sludge; probably representing the partially digested remains of planktonic foods obtained in lower San Francisco Bay or the ocean. It was possible to recognize in the mass: Copepoda, Diatomaceae, Rotifera, and Euglena. Also not mentioned in the table are several cases of rotifers present in the stomachs, and feathers in two stomachs listed as empty, as well as two feathers in one of the other stomachs.

While not definitely knowing the lapse of time of the migration from the Golden Gate (San Francisco) to Pittsburg, it seems logical to assume that the shad of the river system actively feed on *Neomysis*, copepods and other planktonic organisms during the spawning migration while they are in the brackish waters of the lower Bay and Delta.

An additional series of adult shad stomachs was taken during 1939 in the upper Delta from fresh water. This sample consisted of 14 specimens taken at Hood during July, two taken in the lower Mokelumne River on June 27, and two from the American River on June 27. With one exception, these stomachs contained only two seed pods, bits of decayed wood and greenish mucus in the intestines. The exception was a female with well developed roe taken at Hood on July 21, whose stomach contained numerous Cladocera and Copepoda. In view of the results of previous workers on this subject as well as data obtained during this investigation, it seems reasonable to conclude that migrating shad do not actively feed while in fresh water.

POSSIBLE IMPROVEMENTS OF EXISTING CONDITIONS AFFECTING FISH LIFE

Present provisions for protective devices to maintain fish life under present conditions in the San Joaquin system are very inadequate. The seriousness of this situation will become more acute with the inevitable influences against the fish populations to follow the completion of the Water Project. Fluctuating water levels, pollution, unscreened diversions, pumps and siphons each year take an enormous toll of fish life.

As part of this survey, material has been assembled on situations where improvements on existing conditions are possible. First and

foremost among the desired improvements are adequate fish screens on the irrigation diversions throughout the San Joaquin River system and the Delta region. The majority of these diversions have been mentioned previously. The presence of hundreds of unscreened pumps and siphons throughout the area also constitutes a serious menace to small fish. A list of these is given in appendix C.

Improvement of other conditions is so dependent upon the water supply that it may be impractical, in view of pressing irrigation and hydro-electric needs. Specifically may be mentioned the Merced River, where an additional water supply would increase the available salmon spawning areas, and the Cosumnes, which is completely dried up in the lower reaches during a great part of the year. Salmon spawning activities in some streams are jeopardized by fluctuating water levels; this is especially true in the Stanislaus River and to a lesser degree in the Mokelumne River. Mention has also been made of the diversion of water on the San Joaquin River to such an extent that the fall run of salmon has all but disappeared, and a similar problem is encountered in a lesser degree at the Woodbridge Dam on the Mokelumne River. Suddenly lowering the water flow below the dam to counteract a decreased flow from the Pardee Dam above, leaves many salmon stranded on the rocks and prevents any fish from ascending the fishway. (See Fig. 132.)

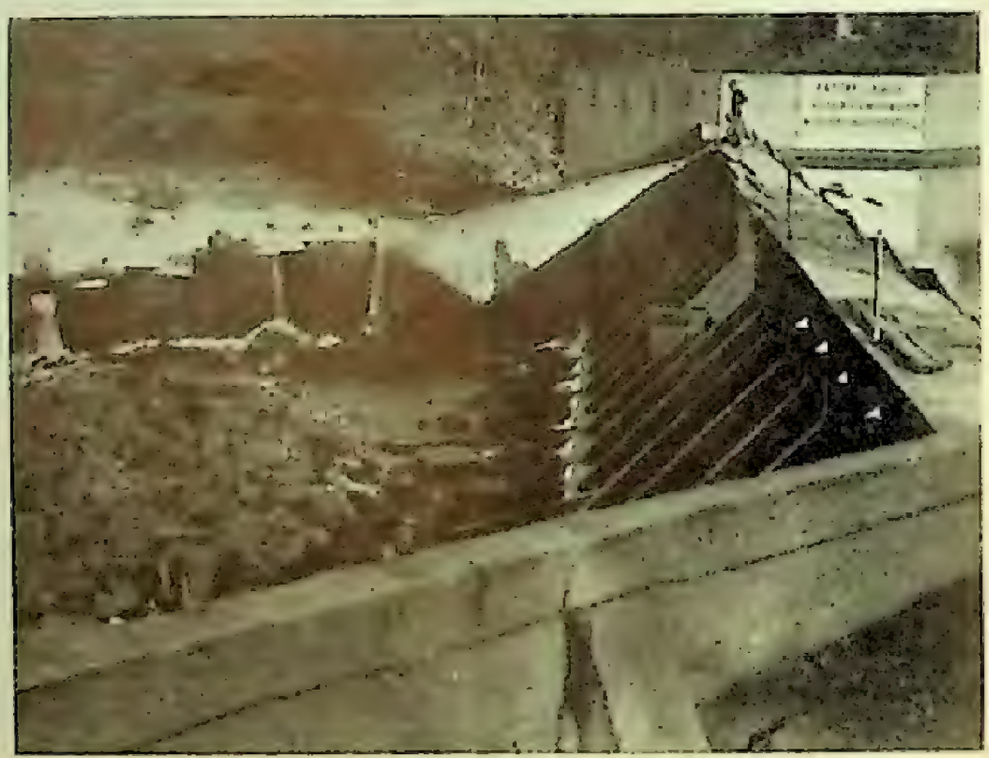

Fig. 132. Woodbridge Dam on the Mokelumne River, showing water conditions when salmon are unable to reach the foot of the fishway and become stranded on the rocks below the dam. Photograph by author.

Pollution in a serious form was observed only on the Mokelumne River. It has been the practice of the several wineries along the stream to dispose of the sludge from their vats into the river, and unfortunately this dumping coincides with the time of the fall salmon run. Evidence is available to show that this pollutant is

lethal to fish life and its presence in the stream is just as effective in blocking the spawning migration as any obstruction. The run of salmon in the fall of 1939 up the Mokelumne and its tributary, the Cosumnes, started only after dumping of the sludge had ceased at the end of the grape harvest. Prior to that time several hundred dead salmon, in addition to other species, were noted on the river banks below the wineries. However, in the fall of 1939 an agreement was reached between the California Division of Fish and Game and the wineries to clear up this pollution problem.

Another factor tending to decrease the population of salmon in the San Joaquin area is the general practice of spearing these fish during their migration or while they are actually on the nests. With the exception of the lower part of the Stanislaus River and Tuolumne River, spearing is prohibited on these streams. Without the support of the general public, however, the law is very difficult to enforce.

SUMMARY

1. During the period of March 6 to May 9, 1939, the peak of the seaward salmon migration past Hood on the Sacramento River occurred on March 16 and 17, with a lesser peak on March 23, 24 and 25. Two-thirds of the total number of migrants passed Hood during March.

The average size range of the migrants was from 38.54 to 53.14 mm., total length.

2. Small salmon at Hood were found to be most numerous in the upper 8 feet of water and within 70 feet of the bank.

3. During the latter part of the migration at Hood with clearing waters, the nocturnal migration may exceed that of the diurnal.

4. During the period of March 13 to May 19, 1939, the peak of the seaward salmon migration past Mossdale on the San Joaquin River was probably on April 17 and 18, with a secondary peak occurring from April 1 to 4. Approximately two-thirds of the migrants were taken during April. The fry ranged in average size from 40.95 to 73.90 mm. during the period of the investigation.

5. Data are accumulated to show that the majority of the migrants at Mossdale descend near the middle of the channel, and that the individuals near mid-stream are significantly larger than those nearer the stream edges.

6. During the period of April 6 to 21, 1939, migrant salmon fry were taken in the Feather River at Verona at an average total length of 39.27 to 41.00 mm. During the same period, migrating fry were found to be practically absent in the Sacramento River at Verona.

7. The first seaward migrating salmon in 1939 were taken at Martinez on March 23, and the run continued until near the end of May. The peak of the migration occurred on March 27 and 28. During this period the weekly average total length increased from 39.46 to 74.39 mm.

8. Striped bass of the 1939 season's spawning were first taken at Hood on August 3 and from then until the week ending October 28, they were taken in varying amounts. During this period the weekly average total length of the fish increased from 53 to 88.40 mm.

9. The number of striped bass taken and the size when first intercepted would indicate that there is no definite seaward migration of immature striped bass past Hood.

10. Striped bass of the 1939 season's spawning were first taken at Martinez on June 14, 1939 at an average total length of 26 mm. Thereafter, until the last of June, 1940, they were taken regularly, during which time the average length increased to a high average of 113.10 mm. during the week ending December 2, 1939.

11. Striped bass of the year were most abundant at Martinez from July 30 to August 12, 1939.

12. Shad of the year were taken at Hood on June 23, 1939 at an average total length of about 20 mm. From that time until the last specimens were taken near the end of October, the average length increased to 80 mm.

13. The peak of the seaward shad migration at Hood occurred during the week ending August 26, 1939. A secondary peak occurred during the week ending July 8.

14. Small shad appeared in numbers at Martinez on May 4, 1939, and the migration continued until January of 1940. During this period the average length of the fish increased from 33 to 114 mm.

15. Immature shad at Martinez were most numerous during the week ending May 6, 1939.

16. The peak of the shad spawning migration at Martinez was from May 15 to June 1, 1939; the peak at Hood was from May 23 to June 6, 1939; in the Sacramento and Feather rivers, in the vicinity of Colusa and Marysville, adult shad were most numerous around June 10, 1939.

17. The salmon spawning area of the Cosumnes River extends from the Sloughhouse Bridge to a point one-half mile below the Latrobe Highway Bridge, a linear distance of 15.2 miles. In this area, 117,263 square feet of suitable salmon spawning grounds is encompassed, which represents a total spawning capacity of 5,864 fish.

18. The salmon spawning beds of the Mokelumne River extend from the Lockford Bridge to the Pardee Dam, a distance of 22.5 miles. Within this distance are 381,411 square feet of suitable spawning grounds, representing a carrying capacity of 19,070 salmon.

19. On the Stanislaus River the salmon spawning beds extend from the Riverbank Bridge to the Malone Power House, a distance of 32.7 miles. This stream has 144,686 square feet of available spawning area, and is capable of supporting a run of 7,234 salmon.

20. Between a point 2.2 miles below the railroad bridge at Waterford and the La Grange Power House on the Tuolumne River are 193,806 square feet of area suitable for salmon spawning. This represents a spawning capacity of 9,690 salmon.

21. Suitable salmon spawning areas on the Merced River are encountered from a point one-half mile downstream from a line run due south of Balico to the Exchequer Dam, a distance of 42.4 miles. Within this area are 57,993 square feet of spawning area, or the equivalent of a total spawning capacity of 2,900 salmon.

22. On the San Joaquin River, spawning beds occur from Lane's Bridge to the Kerckhoff Power House, a linear distance of 26 miles. Of this distance 414,772 square feet are suitable for spawning. This stream is capable of supporting a run of 20,738 salmon.

23. Friant Dam will destroy 35.7 per cent of the salmon spawning area of the San Joaquin River.

24. The shad spawning areas of the Sacramento-San Joaquin system are located above the point of saline invasion. Heavy spawning occurs near the limit of tidal influence and in the two rivers and tributary streams.

25. Shad spawning areas may be detected by the presence of ripe specimens of both sexes, by the presence of fertilized eggs and often by "washing" of the spawning fish.

26. The analysis of 224 stomachs from adult striped bass taken at Pittsburg show that salmon form no part of their diet in the lower Sacramento River.

27. The food of small striped bass at Martinez during September and November, 1939, as determined from a sample of 76 stomachs, consisted mainly of isopods and amphipods.

28. A sample of 58 small bass stomachs taken at Martinez during February and March, 1940, when the waters were fresh, showed the principal food item to be a species of Mysidacea.

29. The advent of fresh water at Martinez, resulting from the winter floods, caused no noticeable change in abundance of immature striped bass.

30. Migrating adult shad appear to actively feed while in the brackish waters of San Francisco Bay, but generally cease feeding while on the spawning grounds in fresh water.

31. Conditions adversely affecting the fish populations of the Central Valley that admit of improvement are mainly: insufficient water for a normal migration of adult fish; the presence of many unscreened diversions, pumps and flood gates; and pollution.

REFERENCES

Brice, John C.
1897. A manual of fish-culture. U. S. Commissioner of Fish and Fisheries. Report, 1897, pp. 1-340.

Clark, G. H.
1929. Sacramento-San Joaquin salmon (*Oncorhynchus tschawytscha*) fishery of California. California Division of Fish and Game. Fish Bulletin, no. 17, 73 pp.

Hanson, Harry A.; Smith, Osgood R.; and Needham, Paul R.
1940. An investigation of fish-salvage problems in relation to Shasta Dam. U. S. Bureau of Fisheries. Special Scientific Report, no. 10, 200 pp. (mimeographed).

Leidy, J.
1868. Remarks on shad brought to our markets during the late autumnal months, which were caught in salt water, and their food. Academy of Natural Sciences of Philadelphia. Proceedings, 1868, p. 228.

Leim, A. H.
1924. The life-history of the shad (*Alosa sapidissima* (Wilson)) with special reference to the factors limiting its abundance. Contributions to Canadian Biology, n. s., vol. 2, no. 11, pp. 161-284.

Nidever, H. B.
1916. Shad in California. California Fish and Game, vol. 2, pp. 59-64.

Pearson, John C.
1938. The life history of the striped bass, or rockfish, *Roccus saxatilis* (Walbaum). U. S. Bureau of Fisheries. Bulletin, vol. 28, pp. 825-851.

Rich, Willis H.
1920. Early history and seaward migration of chinook salmon in the Columbia and Sacramento rivers. U. S. Bureau of Fisheries. Bulletin, vol. 37, doc. 887, pp. 1-73.

Rutter, Cloudsley
1903. Natural history of the quinnat salmon. A report on investigations in the Sacramento River, 1896-1901. U. S. Fish Commission. Bulletin, vol. 22, pp. 65-141.

Scofield, E. C.
1928.1. Striped bass studies. California Fish and Game, vol. 14, pp. 29-37.
1928.2. Preliminary studies on the California striped bass. American Fisheries Society. Transactions, 1928, pp. 139-145.
1931. The striped bass of California (*Roccus lineatus*). California Division of Fish and Game. Fish Bulletin, no. 29, 82 pp.

Scofield, N. B., and Bryant, H. C.
1926. The striped bass in California. California Fish and Game, vol. 12, pp. 55-74.

Scofield, N. B., and Coleman, G. A.
1910. Notes on spawning and hatching of striped bass eggs at Bouldin Island hatchery. California Board of Fish and Game Commissioners. Biennial Report, 1909-10, no. 21, pp. 109-117.

Shapovalov, Leo
1936. Food of the striped bass. California Fish and Game, vol. 22, pp. 262-271.

Smith, H. M.
1896. A review of the history and results of the attempts to acclimatize fish and other water animals in the Pacific states. U. S. Fish Commission. Bulletin, vol. 15, pp. 379-472.

APPENDIX A

STREAM FLOW RECORDS ON DATES OF SALMON SPAWNING SURVEYS *

Cosumnes River at Michigan Bar

	Second Feet
October 10, 1939	36
October 11, 1939	30
October 12, 1939	22
October 13, 1939	20

Mokelumne River at Woodbridge

October 4, 1939	256
October 5, 1939	346
October 6, 1939	283
October 7, 1939	282
October 8, 1939	278
October 9, 1939	114
October 11, 1939	291

Stanislaus River at Malone Power House

November 9, 1939	421
November 10, 1939	425
November 16, 1939	434
November 17, 1939	280
November 18, 1939	111
November 19, 1939	116

NOTE.—Volume of discharge of diversions at Goodwin Dam not available, which should be subtracted from the amount given.

Tuolumne River at La Grange

October 16, 1939	330
October 17, 1939	317
October 18, 1939	302
October 19, 1939	313
October 20, 1939	331
October 21, 1939	345
October 22, 1939	314

NOTE.—Taken from the records of the gauging station above the La Grange Dam, from which the discharge of the Turlock and Modesto canals has been subtracted.

Merced River at Livingston

October 31, 1939	109
November 1, 1939	108
November 2, 1939	108
November 3, 1939	107
November 4, 1939	107
November 5, 1939	106
November 9, 1939	102
November 13, 1939	107
November 14, 1939	106

San Joaquin River at Friant

October 24, 1939	758
October 25, 1939	762
October 26, 1939	912
November 1, 1939	762
November 2, 1939	900
November 3, 1939	1560

* The records were obtained through the courtesy of H. D. McGlashan of the U. S. Geological Survey.

APPENDIX B

COUNTS OF ADULT MIGRANT SALMON

Although incomplete counts of migrant salmon on any one stream are admittedly of little value, counts have been made as time and conditions allowed. The difficulties of making fish counts are increased by the absence of dams or weirs at which these can be made, and where dams and ladders are available the weir boards are generally removed before the completion of the fall run. Counts made of fish on the beds during the survey fall into the same category of usefulness. Counts made during the fall run of 1939, salmon observed during the spawning surveys, and a partial count of the spring run of the San Joaquin River are given in the following table.

Mokelumne River

Counts made at Woodbridge Dam	Number of salmon
November 12, 1939, 9.30 a.m. to 4.15 p.m.	269
November 13, 1939, 7.45 a.m. to 4.30 p.m.	118
November 14, 1939, 7.30 a.m. to 5.30 p.m.	1
November 15, 1939, 10.20 a.m. to 5.30 p.m.	277
November 16, 1939, 7 a.m. to 5. p.m.	859

The weir boards were removed on November 17, 1939.

Tuolumne River

Counts made at Modesto Weir

October 13, 1939, 9.15 a.m. to 10.15 a.m.	20
October 14, 1939, 7 a.m. to 11 a.m.	213
October 20, 1939, 8 a.m. to 9 a.m.	25
October 21, 1939, 8 a.m. to 11 a.m.	9
October 23, 1939, 7.30 a.m. to 12 Noon	40

Merced River

260 salmon counted on spawning beds during survey.

San Joaquin River

Counts made at Mendota Weir

	Number of counting hours	Number of salmon
May 4, 1939	10	49
May 5, 1939	4	37
May 8, 1939	4	9
May 9, 1939	9	69
May 10, 1939	9	74
May 11, 1939	10	40
May 12, 1939	3	7
May 13, 1939	7½	24
May 15, 1939	5	5
May 16, 1939	11	26
May 17, 1939	9	11
May 18, 1939	8	8
May 19, 1939	11	6
May 20, 1939	4	3
Total		368

APPENDIX C

Number and Size of Pumps on Streams of the San Joaquin River System*

Diameter of pipe, inches	Cosumnes River	Mokelumne River	Stanislaus River	Tuolumne River	Merced River	San Joaquin River	Delta Region
2	3						
4		3			4	1	10
6	1	11	2	5	15	2	44
8	11	13	2	4	9	2	130
10	4	7	5	4	4	2	383
12	4	10	2	3	9	10	195
14			2	1	1	3	8
15			1		1	2	1
16			2	1	1	1	50
18	1						12
20						6	20
24							17
30						3	6
36					1	7	8
42						1	
Totals	24	44	16	18	45	40	890
Grand total							1,164

* Some of these pumps are provided with brush screens, with meshes ranging in size between one and five inches.

Number and Size of Pumps on the Sacramento River from Ord's Ferry to Collinsville

Diameter of pumps, inches	Number of pumps	Diameter of pumps, inches	Number of pumps
4	2	20	4
6	45	24	19
8	82	30	9
10	128	36	15
12	72	48	4
14	8		
16	20	Total	420
18	12		

THE UTILIZATION OF THE CALIFORNIA CRAB RESOURCE [1]

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A commercial fishery is developed because of the presence of a given species and its availability to fishermen using various types of fishing gear. The growth of such a fishery depends not only on the distribution of the species and the supply available year after year but likewise upon the demand for the product.

Many of California's fisheries have been fished very heavily wherever found throughout the State, but in the case of the crab (*Cancer magister*) the fishing grounds throughout its known distribution in California have been utilized only to a limited extent. This condition is attributable to two causes: First, crabs are not a staple article of diet but supply the demand of a more or less luxury trade; and second, the control of the industry in California has been in the hands of a small organized group. This control has for many years discouraged any free-lance crab fishing and the importation of "outside" crabs. The retail dealers have been arbitrarily informed as to the number of crabs they should handle and the price they should pay for them, regardless of the supply and demand. Little effort has been made to extend the market beyond the San Francisco Bay area, as increased sales would have forced an extension of the fishing territory or necessitated the importation of crabs, with a possible weakening of the control.

The crab fishery has passed through the various legal stages common to most of the fisheries of the State. As a virgin resource, no restrictions were considered necessary, but as fishing effort and consequent landings increased, regulations were gradually imposed. In 1895 the Legislature enacted the law which prohibited taking or possessing female crabs. In 1903 legislation made it illegal to take any crab of less than six inches across the back. The size limit was amended to seven inches in 1911, and this limit has remained in effect since that time. The closed season enacted in 1903 (September 1-November 1) was amended by the Legislature in 1909 to November 1-March 1, and subsequently amended into the present closed season of August 16-October 31 for the San Francisco and Monterey regions (Districts 10, 11, 17), and August 31-December 14, for Humboldt, Del Norte and Mendocino counties (Districts 1½, 5, 6, 7, 8, 9). The present crab law provides ample protection to the species because it allows the taking of only male mature crabs of seven inches or larger. Consequently, all females are protected to reproduce, and the fishery is entirely based on the surplus males above the size limit, so depletion of the crab population is very improbable.

A study of the catch figures for crabs (see Fig. 134) compiled by the Bureau of Marine Fisheries since 1916, together with a knowl-

[1] Submitted for publication, September, 1940.

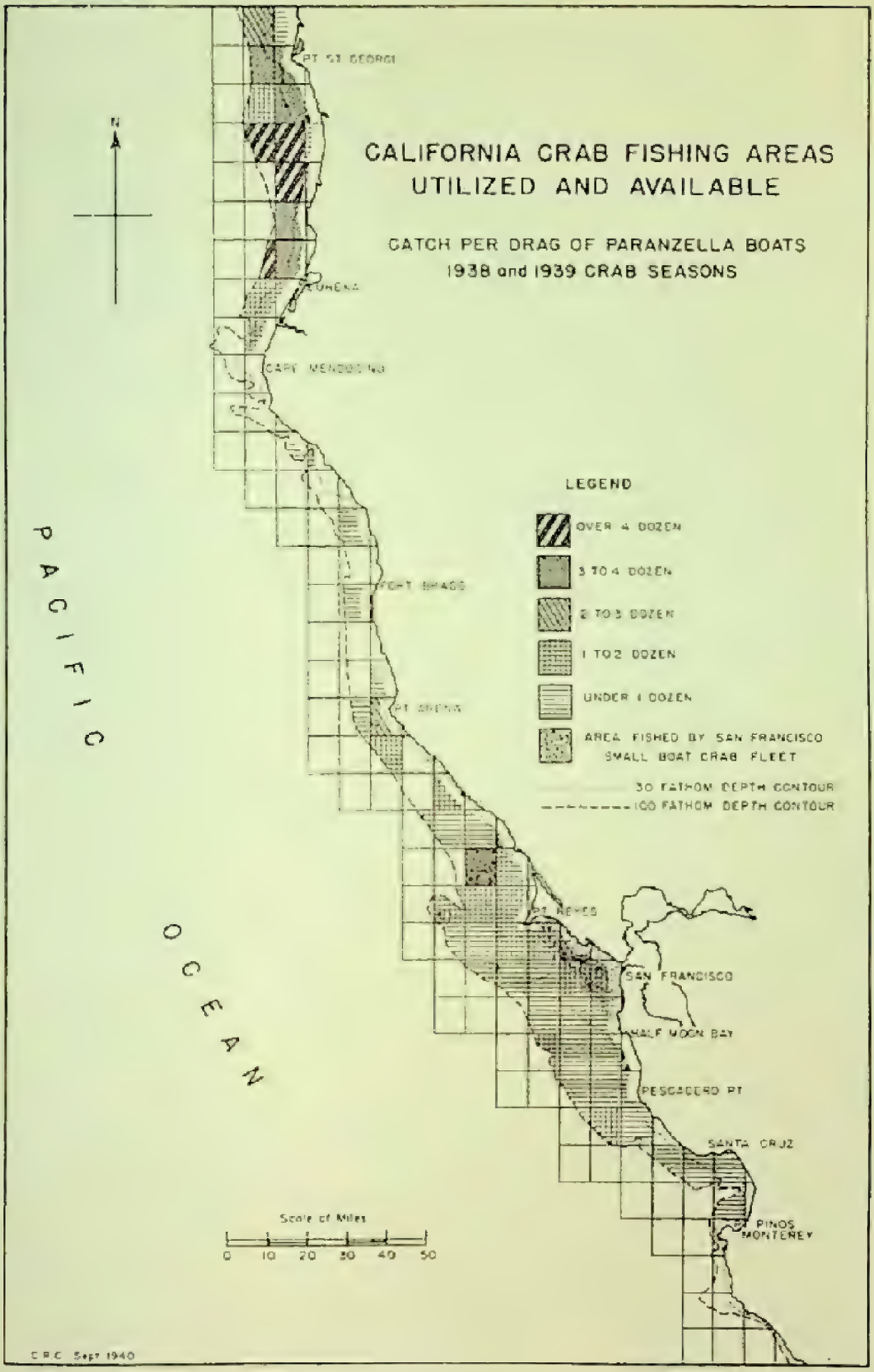

FIG. 133. The range of the market crab in California, showing the areas now fished and those capable of exploitation.

edge of the life-history and ecology of the species and some familiarity with the particulars pertaining to the crab fishing industry, demonstrate several pertinent and instructive facts.

As a luxury product, a conception that has been at least partly engendered by the imposition and maintenance of an unwarranted high price level, the demand for crabs actually reflects the general economic status of the country. During periods of prosperity the demand increases, while in times of depression there is a sharp reduction in sales and consequent fishing effort and production.

This is readily demonstrated by figure 134. It is apparent that the curves representing San Francisco crab landings rise and fall in sympathy with the various disturbances in the financial solvency of the buying public. The high catch, as shown in the curve for the season 1937-38, is an exception. It is merely the visible corroboration of a vindictive price war inaugurated to combat imports of crabs from Washington, Oregon and Eureka districts.

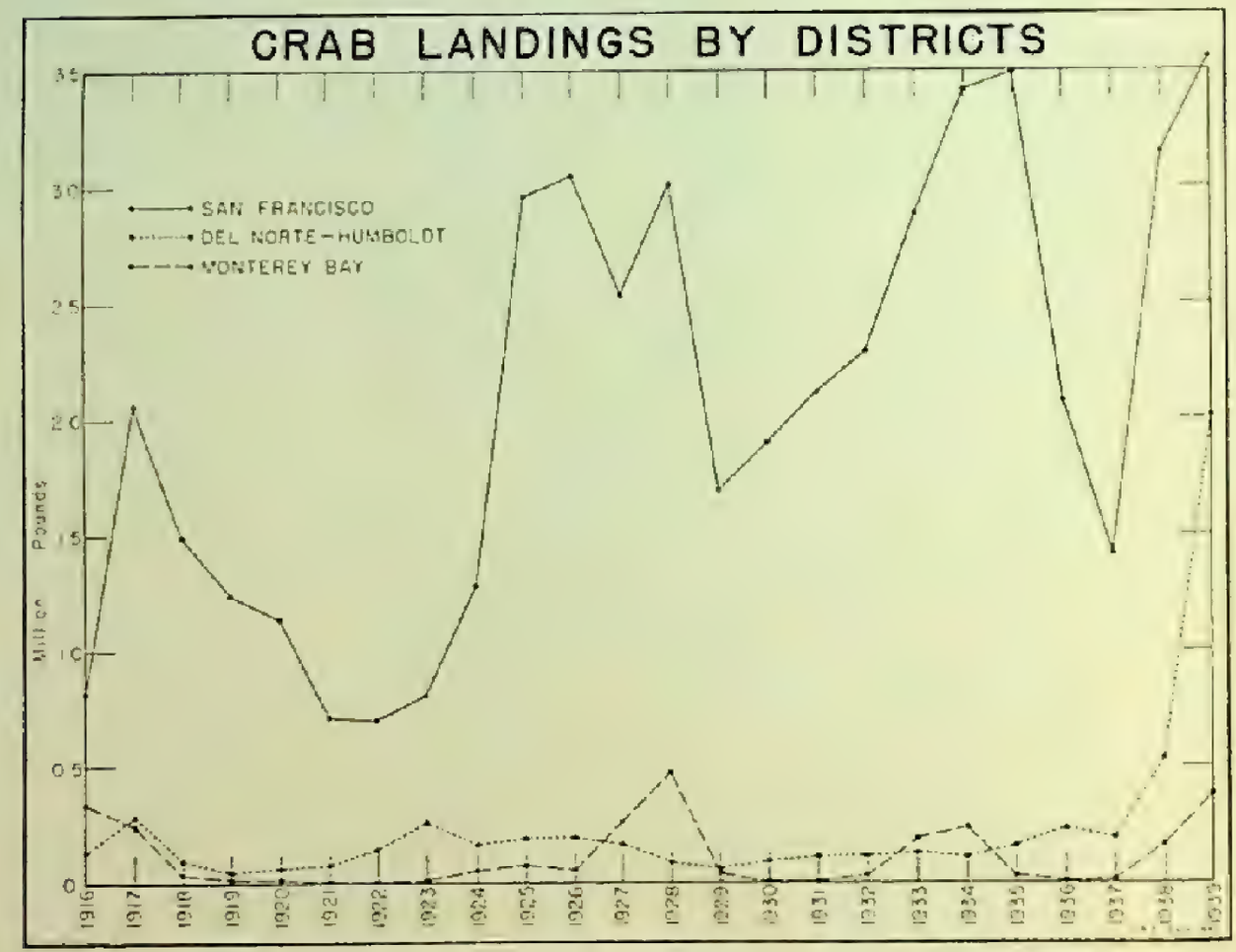

Fig. 134. Annual commercial crab catches by districts, 1916 to 1939.

Although the majority of California crabs have been taken near San Francisco, they also occur in abundance in other parts of the coast. (See Fig. 133.) The Monterey area supplies a considerable quantity spasmodically but is not a reliable source of supply as during some seasons crabs are almost totally absent. This may be due to the fact that Monterey Bay is on the southern fringe of the crab distribution and survival of crab spawning is only occasional.

The Humboldt-Del Norte region is a prolific crab territory, but very few crabs have been taken there in recent years. In 1917 a State law was enacted at the request of the local organizations in Del Norte, Humboldt and Mendocino counties, which forbade the shipment of crabs from the districts which comprise these counties. To justify this legislation, it was claimed that commercial fishing would deplete the supply of crabs and that if exporting were permitted, the local population would be forced to pay a higher price for their crabs. However, with an enforced size limit of seven inches, depletion is not likely. Moreover, no increase in price would result, as the increased landings of crabs would make more available for the local as well as the "export" markets. The local organizations that originally sponsored the non-export bill have not been so aggressive in recent years, but all efforts to change or repeal the law have been promptly and effectively nullified by a combination of a few local people and by San Francisco crab interests.

The San Francisco catch figures reveal additional significant points. It is evident that the heaviest landings occur during the first months of the open season, progressively decreasing thereafter until toward the end of the season there are apparently few legal sized crabs remaining in the fished area. (See Fig. 135.) There was a decrease in the catch also between 1935, when the open season was extended fifteen days at each end, and 1937. The season in effect prior to 1935 evidently satisfactorily performed the task for which it was created and protected the crabs during the spawning and molting period. The extended season evidently encroaches somewhat on this interval, so necessary to the well-being of the species.

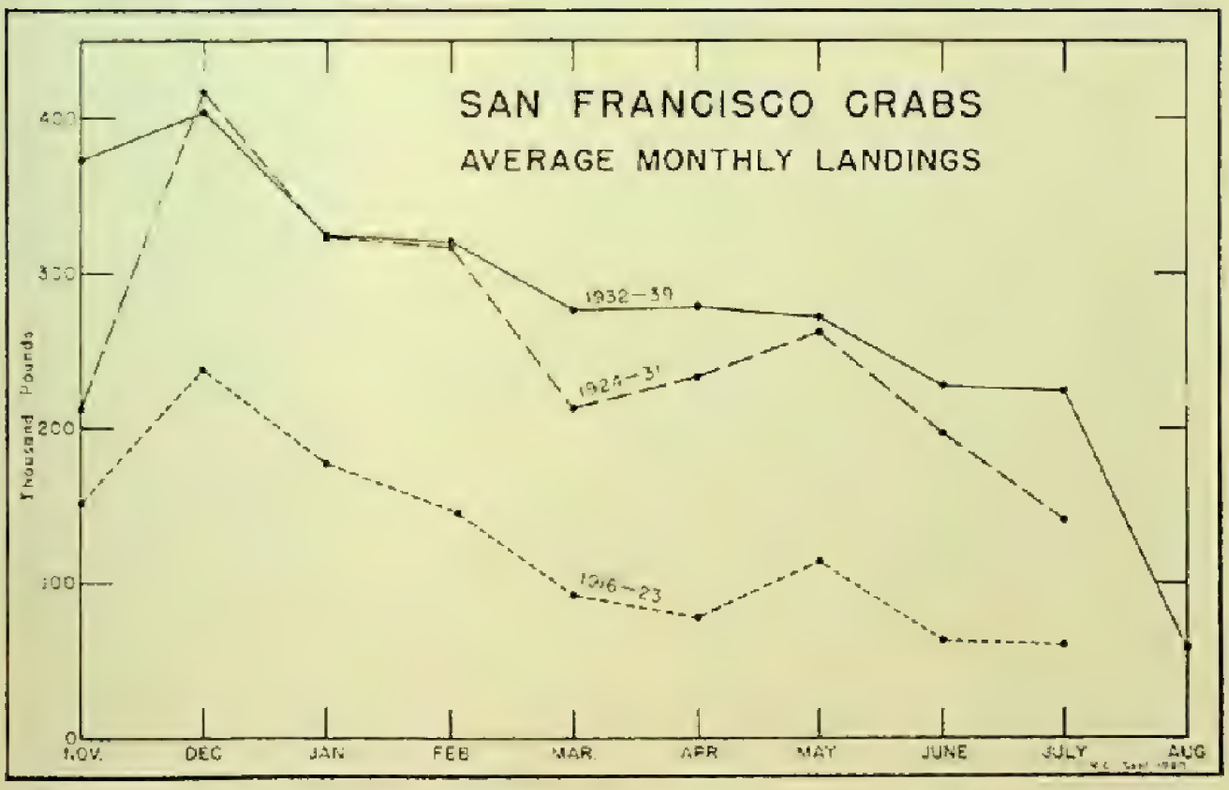

FIG. 135. Average monthly landings of crabs in the San Francisco region, by eight-year periods. Note that in all cases, heavy early season landings are followed by lighter catches as the season advances.

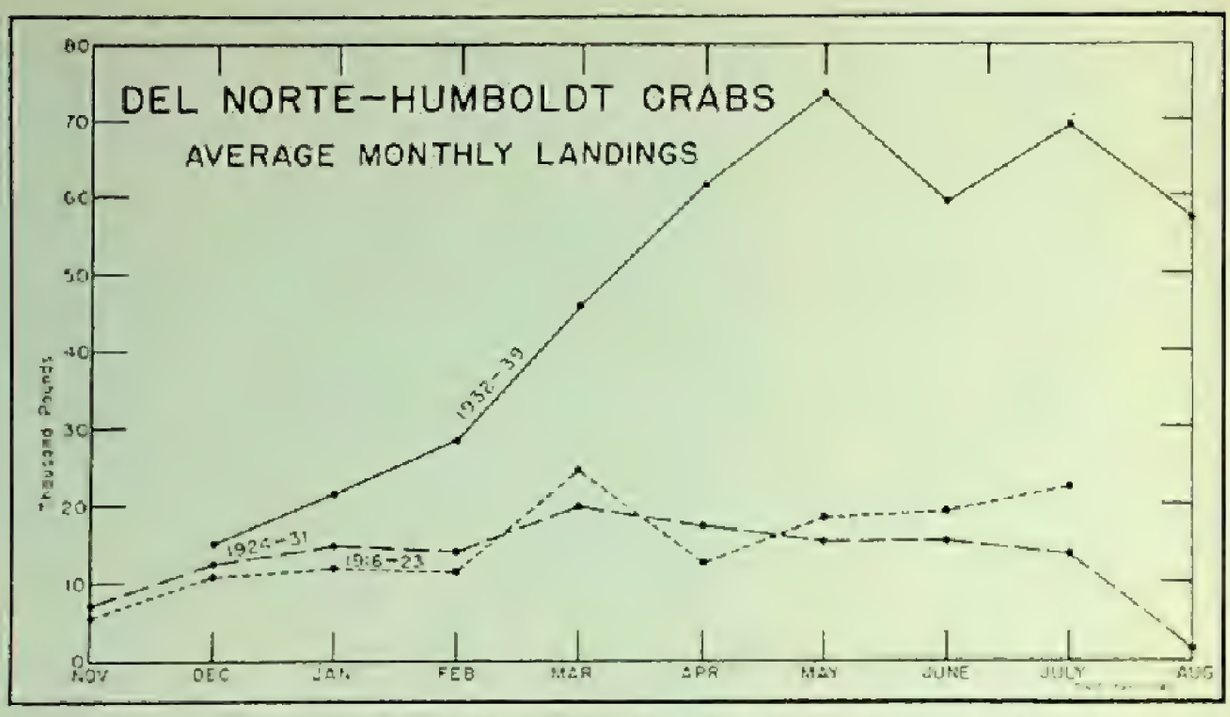

FIG. 136. Average monthly landings of crabs in the Del Norte-Humboldt district, by eight-year periods. Note that catches do not drop off as the season advances. (See Fig. 135.)

The marketing methods employed and the comparatively high price have restricted the crab fishery in the past, so that an arbitrary balance had been more or less maintained between supply and demand. The market would have absorbed and is now absorbing, by shipments into the State, many more crabs at a lower price. The California coastal area could supply many times the number taken at present if the industry were on the same competitive basis extant in other enterprises.

The San Francisco crab fishermen utilize an area of approximately 240 square miles (see Fig. 133), an area which occupies a centralized position within a region of potential crab ground containing 400 square miles to the 30 fathom line, and 1200 square miles to the 100 fathom mark. In the Humboldt region, a few fishermen have recently taken crabs off shore and the drag boats working in that section have for several years taken appreciable quantities incidental to their regular catches of fish. Perhaps because this territory has been little used for crab fishing the crabs are exceptionally plentiful and very large, the majority being from $7\frac{1}{2}$ to $8\frac{1}{2}$ inches.

Under the protection of a recent (1938) court ruling, the Eureka fishermen have been shipping to San Francisco the crabs "taken outside the three-mile limit"; and crabs are also being imported from Oregon and Washington. These crabs yield a profit to the fisherman and wholesaler, although laid down in San Francisco for $1.50 to $1.75 a dozen. The San Francisco retailers have paid $2.50 a dozen for years.

The following table gives an idea of the territory on the California coast available to the crab fishermen. (See also Fig. 133.)

TABLE 1

Potential Crab Fishing Area on the California Coast

Coastal area	Number of square miles from		
	Shore to 30 fathoms	Shore to 100 fathoms	3-mile limit to 100 fathom line
Oregon line to Cape Mendocino	560	1,200	720
Cape Mendocino to Pt. Arena	160	480	110
Pt. Arena to Pt. Reyes	160	800	560
Pt. Reyes to Pescadero Pt.	*400	1,200	960
Pescadero Pt. to Pt. Pinos	150	400	240
Totals	1,430	4,080	2,590

* 240 square miles used by San Francisco crab fleet.

Some portions of the bottom are unsuitable for crabs and they will not thrive. Other sections could be fished only with extreme difficulty, but there are great areas of bottom supporting a prolific crab population which are not being utilized at all. Many thousands of crabs annually die of old age on these grounds, which constitutes an enormous economic waste. This has continued principally because of the suppression of competition and misconception of the proper method of conservation of the crab fishery.

From the conservation as well as the economic viewpoint, the crab fisheries of the several ports could be adjusted. As suggestions:

1. The San Francisco crab industry should expand its markets to a larger area than the confines of the Bay region in order to deal in volume of crabs rather than in small amounts at a controlled price. By so doing, it will be able to meet competitive prices of crabs shipped from other ports, and at the same time by dealing in volume the fishermen can make a living wage.

2. It would be desirable for fishermen and wholesalers to grade and sell crabs according to size.

3. In order to increase the amount of crabs landed, it will be necessary to extend fishing operations in all regions to coincide with the known distribution of crabs (see Table 1 and Fig. 133) into unfished territory and deeper water.

4. In order to properly utilize the natural resource of crabs in Districts 5, 6 and 7 (Del Norte, Humboldt and Mendocino counties), the law should be changed so that crabs taken in these districts can be shipped anywhere in the State. The present size limit and restrictions on taking female crabs should remain in force.

5. The closed season in the San Francisco region should be changed to August 1-November 15, in order to protect the molting crabs.

TABLE 2

California Crab Landings by Districts, 1916-1939

Expressed in Pounds

Year	Monterey and Santa Cruz	San Francisco*	Mendocino and Sonoma	Del Norte and Humboldt	State totals
1916	345,336	819,144	2,424	130,008	1,296,912
1917	244,872	2,054,472	----------	281,496	2,580,840
1918	29,712	1,490,496	----------	99,072	1,619,280
1919	13,224	1,246,440	----------	45,168	1,304,832
1920	11,712	1,143,840	----------	65,016	1,220,568
1921	3,432	714,936	4,392	78,192	800,952
1922	2,472	702,672	13,968	143,016	862,128
1923	7,416	807,264	6,480	254,640	1,075,800
1924	50,304	1,285,536	3,864	167,112	1,506,816
1925	74,568	2,962,800	13,200	183,744	3,234,312
1926	51,504	3,050,112	1,584	193,080	3,296,280
1927	259,320	2,530,080	192	161,520	2,960,712
1928	473,616	3,014,760	1,128	86,280	3,575,784
1929	37,296	1,691,784	----------	63,696	1,792,776
1930	1,104	1,898,832	----------	92,448	1,992,384
1931	2,544	2,116,139	162	111,040	2,231,384
1932	27,398	2,285,799	4,332	116,458	2,433,987
1933	188,044	2,889,080	4,646	126,724	3,208,494
1934	235,272	3,415,438	6,720	110,651	3,768,081
1935	26,680	3,491,226	4,828	156,518	3,679,252
1936	6,256	2,072,896	2,750	229,000	2,311,802
1937	12,108	1,419,441	4,080	192,020	1,627,649
1938	167,970	3,152,950	21,988	530,692	3,873,600
1939	378,136	3,554,328	7,088	2,004,953	5,944,505

* Including Marin, Alameda and San Mateo counties.

TENTH ANNUAL BLACK BRANT CENSUS IN CALIFORNIA[1]

By James Moffitt

California Academy of Sciences

When the writer instituted these annual censuses of the wintering black brant (*Branta bernicla nigricans*) population of the California coast in 1931 as an employee of the State Division of Fish and Game it was his intention to conduct them for ten consecutive years. This time has now elapsed and ten satisfactory annual counts are at hand for two of the main areas, Tomales and Mission-San Diego bays. Since, however, no censuses were attempted in 1931 at Bodega and Drake's bays, the 1933 count was not made at Morro Bay, and an unsatisfactory result was obtained in 1931 at Humboldt Bay, it has been decided to continue the censuses at all points for another season that reports for ten years may be had for all localities.

The tenth annual brant census was conducted at the customary time this year. All counts save the writer's at Tomales Bay were made on February 10. As usual, members of the Bureau of Patrol of the California Division of Fish and Game were active cooperators in this work and thanks are gratefully acknowledged for the assistance rendered by the game wardens mentioned beyond. Thanks are also due to Dr. A. P. Marshall, San Luis Obispo, for assistance with the census at Morro Bay, and to Messrs. C. G. Abbott and Earl Warren of San Diego, who helped in that locality. The reports for the various areas follow:

Humboldt Bay

Game wardens L. E. Lahr and J. F. Hurley took the brant census on this bay on February 10, 1940. Lahr's report of this date, quoted below, reveals that large numbers of brant were present. The total, 56,375 birds, is the second largest obtained in nine consecutive annual counts in this locality and is exceeded only by the census of 1935 when nearly twice as many brant, 105,000 birds, were reported.

> "Taking advantage of a high tide we made trips to practically every part of North and South Humboldt Bay, using the State patrol boat. Brant were particularly plentiful in South Humboldt Bay. From the South Jetty to the foot of Table Bluff, a distance of about four miles by water, there was a continuous raft of brant about 50 yards in width. From the foot of Table Bluff easterly toward Beatrice another flock of similar width extended for at least three miles. In addition to these there were numerous smaller flocks of from 25 to 250 birds resting in the middle of the bay. Many times large flights arose like a black cloud of birds. Warden Hurley has worked this district for years and it is his opinion that there are more brant here now than at any time in his memory. Working the flocks and rafts as carefully

[1] Submitted for publication, August, 1940.

as possible we estimated there are at least 50,000 brant in South Humboldt Bay. North Humboldt Bay was thoroughly worked, trips were made to the vicinity of the old Arcata Wharf, Jacoby Creek, Mad River Slough, Ryan Slough and Brainard. Here we found the flocks to be smaller, ranging in size from 10 to 150 birds, though several large rafts were checked that went to 1000 or more birds; most of the birds were put up from along the shore between Jacoby Creek and Ryan Slough. Our total count here was 6,375 brant. In addition to this we observed some 20,000 ducks, mostly sprig, baldpate, bluebill and teal.

"The weather was clear most of the day with light squalls of rain from time to time; brisk winds kept the birds in the bay so that it was comparatively easy to avoid a duplicate count of the flocks. The total brant at Humboldt Bay will number about 56,375."

Bodega Bay

Game Warden Ralph Miller counted the brant on Bodega Bay the morning of February 10, 1940. An accurate census totaling 1,050 birds was secured. At the time, several residents of Bodega Bay commented to Miller that there were not as many brant on the bay this year as in previous ones. This fact is borne out by the census of 1940, which is the third smallest on record for nine consecutive years, but it is only 50 birds less than the 1939 total. In 1936, only 350 brant were counted on Bodega Bay and 977 birds in 1933. The largest census was obtained here in 1935 when 3,700 brant were reported. It is possible that an increasing amount of human activity on and about Bodega Bay, a relatively small body of water, is tending to drive the brant from the vicinity.

Tomales Bay

The writer's attempt to count the brant on Tomales Bay the morning of February 10, 1940, concurrent with the other censuses, was prevented for the second consecutive year by failure of an outboard motor to operate. Accordingly, the census was made here on the next available day, February 17, which is the date upon which the 1939 count was made. The total of 4,916 brant secured in 1940 was considered to be accurate within only about 80 per cent. In other words, there may have been 20 per cent more or fewer brant present. In the morning, a large flock estimated at 4,000 birds was feeding in the middle of the bay between Hog Island and Tom's Point. It was then impossible to secure more than an approximation of its number. This aggregation scattered somewhat after noon when some of its members flew to other parts of the bay. The remaining brant totaled 3,475 birds in a satisfactory count. Estimating that about 500 individuals had left the area since morning, confirmed the earlier figure of 4,000 birds. Only 56 brant were found on the outer bay (the area between Tom's Point and the ocean). Few birds have been observed in this part of the bay at any season for several years, whereas in the earlier censuses many were often found there. For instance in 1932 (see map, California Fish and Game, vol. 18, 1932, p. 301), the majority of the birds counted were on the outer bay. The eel grass supply does not appear to be so plentiful on the outer bay as formerly, and this is probably the main reason why few brant are now found

there. Also, increasing numbers of fishermen and clammers in late years disturb the birds in this vicinity more than formerly.

The 1940 total compares rather unfavorably with the previous nine years' average of 6,511 brant for Tomales Bay, but wide fluctuations exist in the February censuses, so there is no occasion for alarm. The second largest annual total, 9,241 brant, was recorded for this bay in 1939, while the previous year but 3,085 were counted and only 1,556 in 1937. The exceptionally large number recorded at Humboldt Bay in 1940 offsets the reduction at Tomales Bay and may well have included birds that were counted the previous year at the latter point.

Drake's Bay

For the third year in succession, Game Warden R. J. Yates counted the brant on this bay. Fog the morning of February 10, at the time of low tide when most brant were to be expected in the bay, prevented taking the census until afternoon when the brant were found to be scattered about and difficult to count with a strong wind blowing. For these reasons Yates believes that his total of 4,400 birds is rather unsatisfactory and that more were probably present. He states that he counted 7,800 brant on this bay in January. Nevertheless, 4,400 brant is the second largest of nine annual counts on Drake's Bay, the largest previous one being 6,400 birds recorded in 1939.

Morro Bay

Dr. A. P. Marshall and Game Warden F. W. Hecker, of San Luis Obispo, who have both assisted with several previous censuses at Morro Bay, again counted the brant in 1940. Due to a misunderstanding, the two did not count together, but one in the morning and the other in the afternoon. The results of these independent counts are most gratifying and reflect the care and experience of these observers, for they agree remarkably well.

Hecker's count, since it was made in the morning when most brant were apparently present, is used here for the annual census total. His report follows:

> "This year's brant census was taken on February 10th. Dr. A. P. Marshall was not able to work with me this year, so I made my count in the forenoon, and Dr. Marshall made his count during the afternoon.
>
> "I counted from about 7.45 a.m. until noon, getting a total of 7,263 brant on Morro Bay. During the afternoon I went up the coast as far as Salmon Creek, three miles north of the San Luis Obispo County line. Between San Simeon and the county line I saw a number of brant working off shore from one-half mile to a mile distant. They were too far out, and the ocean too choppy, to make an accurate count, but I would estimate that there were about 350 to 500 birds in that upper coastal area. I would not include these birds in the total, as the brant were getting restless on the bay about the time I finished my count there, and some of them were leaving the bay and heading north. Therefore I believe that the birds I saw along the coast, north of Morro Bay, were birds that left the bay for ocean feeding grounds.
>
> "Dr. Marshall counted during the afternoon, and his total of brant on Morro Bay was 6,993. I believe that the difference in our totals can be accounted for by the birds I saw up the coast, as during our previous counts, working together, there was never such a large difference between our individual totals.

"During the time I made my count, the weather was clear and sunny, with a brisk wind springing up about 11 a.m. For the rest of the period the bay was choppy and the birds started moving about."

In Marshall's report he advised that he counted from 1.30 to 4.30 p.m., from the same observation points used in the previous year's census. The following remarks are excerpted from his report:

"The day was clear, a brisk northwest wind blowing and the tide about half out. The birds were quiet but about 90 per cent of the brant were on the west side of the bay, sheltered by the peninsula, so my count was made from a greater distance than usual. My total was 6,993 brant. No birds were seen to leave the bay or arrive during the count. * * *

"The brant were not as plentiful on the bay during December and January as usual and I don't think the 1940 peak will be reached until late this month or early in March."

The 1940 total of 7,263 brant for Morro Bay compares favorably with the average of 5,759 birds for eight previous censuses, but it is considerably less than the 1939 record count of 11,140 birds. Altogether, the reports at hand seem to indicate a gradual increase of brant at Morro Bay over the past ten years.

Mission and San Diego Bays

Game Warden E. H. Glidden, assisted by C. G. Abbott of the San Diego Natural History Museum and Earl Warren, President of the local Izaak Walton League, took the census in this area the morning of February 10, 1940. Excerpts from Glidden's report follow:

"The brant census was taken on Mission and San Diego bays from 7.45 a.m. until 1 p.m. While impossible to get an accurate count on Mission Bay due to birds being scattered and in rafts, we made a conservative estimate of 1,000 brant east of the Causeway and an almost accurate count of 395 birds west of the Causeway; making a total of 1,395 brant on Mission Bay. The count on San Diego Bay was accurate, 13 birds. Total of both bays was 1,408, which shows an increase of 376 birds over that of 1939.

"Probably due to excessive plane activities over the south bay area both night and day, the brant have moved to more secluded areas such as Mission Bay. Again, it may be attributed to recent dredging by the salt company located on the south end of San Diego Bay which may have caused silt covering or destroying the brant's principal feed, the eel grass."

It is indeed gratifying to have the 1940 census reveal a continuance of the gradual repopulation of this area by brant, which was noted in the last report.

Brant at Point Mugu

A few days before the time of the 1940 brant census, R. S. Croker received a letter from W. C. Welton of the Point Mugu Fishing Resort, near Oxnard, Ventura County, expressing wonder why this locality was not included in the annual censuses, since, he stated, considerable numbers of brant winter there. According to Welton there were large numbers of brant present during December, 1939 and January, 1940, but most of these left by early February due to disturbance by airplanes during war maneuvers. At the time of greatest concentration, he stated that there were far more brant to be seen than at any time in the previous three years.

TABLE I

Recapitulation of California Black Brant Censuses, 1931-1940

Locality	1931	1932	1933	1934	1935
Humboldt Bay	Cream factory	29,415	5,000	16,800	105,000
Bodega Bay	None made	3,200	977	1,298	3,700
Tomales Bay	9,445	6,285	7,409	5,565	6,850
Drake's Bay	None made	2,108	318	2,180	1,995
Morro Bay	4,493	2,938	None made	3,595	7,544
Mission Bay	71	No birds	115	154	0
San Diego Bay	No birds	No birds	No birds	7	55
Totals	Incomplete	43,946	13,819	29,968	125,153

Locality	1936	1937	1938	1939	1940
Humboldt Bay	50,000	22,560	45,000	29,000	50,375
Bodega Bay	350	1,509	1,475	1,100	1,050
Tomales Bay	9,175	1,556	3,085	9,241	4,916
Drake's Bay	1,500	1,500	3,500	6,400	4,400
Morro Bay	5,000	5,331	5,738	11,140	7,263
Mission Bay	30	450	325	570	1,395
San Diego Bay	No birds	350	397	402	13
Totals	66,055	33,187	59,520	57,913	75,412

Croker referred this letter to the writer in time to arrange for a census to be taken at Point Mugu concurrent with the other counts. This census was taken by Game Warden R. E. Bedwell of Santa Barbara on February 10, when he found 500 brant present in the Point Mugu area which includes Mugu Lagoon. In his report, Bedwell stated that he has previously reported to the Fish and Game Commission that brant winter at Point Mugu, but this fact was not known to the writer until he received Welton's letter. Hence, this area has not been included in previous censuses. Bedwell further advised that Mr. Orton, Ventura County Game Warden, reported the presence of about 1,500 brant at Point Mugu for a few days, a short time previous to February 10.

It is apparent from the above that moderate numbers of brant winter at Point Mugu, where, however, according to Bedwell, they do not arrive in numbers until after the hunting season is closed. Small flocks of brant previously reported to the writer as occurring along the Ventura County coast near the mouth of Ventura River, were probably members of the Point Mugu aggregation.

Arrival of Brant at Tomales Bay in Fall of 1939

Brant were rather late in arriving at Tomales Bay in the autumn of 1939. On the writer's first visit to the region on November 11, about 100 birds were observed. Local residents reported seeing none earlier. The brant seen on this day between 6.30 and 8 o'clock in the morning, appeared to be traveling south. At 6.50 a.m., nine birds were observed flying south, extremely high over the mouth of the bay. Fifteen minutes later, eight flew into the bay, low across its entrance. These were followed within twelve minutes by flocks of 8 and 12 birds. Ten minutes later, eight birds returned to the ocean. No more were seen until 8 o'clock, when a flock of about 60 birds flew into the bay

from the ocean. These movements so late in the morning suggested those of new arrivals or of migrating birds; for brant established on Tomales Bay for the winter usually enter the bay from the ocean soon after daylight.

On the next visit to the mouth of Tomales Bay, in the early morning of November 23, 1939, many more brant were observed in the ocean to the north of the bay; but they were still reluctant to enter the bay and had apparently not yet become established there. Thus, at 6.50 a.m., a flock of 15 entered the bay. During the next 20 minutes, flocks of 6, 25, 25, 30 and 7 birds, respectively, flew from the ocean to the entrance whence they turned to fly back to the ocean where they alighted. At 7.30, a flock of 8 birds entered the bay. In the next hour, flocks of 2 and 12 birds flew to the mouth of the bay, then back to the ocean. At 8.25 a.m., fully 500 brant were seen to rise in a cloud from the ocean, fly over it for a short distance, then alight upon it once more. A minute later, a flock of 20 birds, perhaps detached from this main gathering, crossed the bar into Tomales Bay, flew up the bay about a mile, then returned to the ocean. No further activity was observed until 9.30, over an hour later, when a flock of 25 brant came into the outer bay from the ocean, circled it four times, then returned to the ocean. All brant activity then ceased for the morning. In all, only two flocks totaling 23 brant stayed in the bay to feed that morning, whereas several hundred birds were resting offshore on the ocean.

A week later on November 30, brant had become established for the winter on Tomales Bay and regular flights from the ocean to the bay to feed crossed the entrance from 6.50 to 8 a.m. These flocks totaled about 600 birds, rather a small number for so late in the season. The previous night many brant were heard feeding on the mud flats off the mouth of Walker Creek near Hamlet, but they departed for the ocean before daylight and were probably the same individuals that re-entered the bay in the early morning.

A visit to Tomales Bay on January 6, 1940, revealed that relatively few brant were present for the season, not more than 3,000 birds. It is probable that maximum numbers were not attained until after the census of February 17, but no observations were made later in the spring.

Brant Summering at Humboldt Bay

On July 19, 1940, H. M. Worcester, U. S. Game Management Agent for California, telephoned the writer to advise that he had just returned from Eureka where Captain Churchill of the U. S. Coast Guard told him that on July 16, he had seen old and young black brant near Buhne's Point on North Humboldt Bay. This matter is so unusual that we wrote at once to Warden Lahr at Eureka for further information. Lahr reported by letter on July 27 that he visited Buhne's Point the previous day, accompanied by Assistant Warden Bergstrom, where they found 21 adult brant and four young birds about the size of bantam chickens and covered with a shaggy yellowish down. Lahr was not sure that these were young brant, as he had never seen the young of this bird, but he

wrote that they were apparently flightless and that they took to the water from the beach with the peculiar rolling walk of adult brant. Returning to Buhne's Point later in the day, Lahr again found the same flock of old brant on the beach, where they appeared to be quite tame and walked some distance before taking flight. No young were seen at this time.

The writer desired much to go to Humboldt Bay to investigate this report, but was unable to do so. Accordingly, we wrote to a local collector, J. M. Davis of Eureka, on July 30, asking him to collect a young brant for the California Academy of Sciences, as this seemed to be the only way to positively substantiate the breeding record. Davis advised by letter of August 20 that he had spent the greater part of three week-ends searching the vicinity of Buhne's Point for young brant, but that up to this time he had found only 21 adult birds. He wrote further on August 26, that on the 24th he saw four young brant on the sandspit that extends from Buhne's Point to South Humboldt Bay, but that he was unable to collect a specimen. The four young were with two old brant and when he got within 150 yards of them the old ones flew off and the four which he was certain were young, swam away. On his return to the vicinity the next day, Davis failed to see a brant. As this article goes to press on August 28, Davis still hopes that he may secure a young brant to prove this extraordinary breeding record beyond any question.

It is most unusual for as many as 21 old brant to remain as far south as California for the summer. Frequently we find one, two, or three laggard birds, probably ones that were crippled in the previous hunting season, or sick ones, hence unable to migrate, that remain through the summer on California bays (California Fish and Game, vol. 24, 1938, p. 345); but so large a number as 21 has never before been reported.

The brant is an exceedingly far northern breeding species. Black brant are not known to nest south of the Arctic Circle and even nonbreeding individuals appear to summer wholely north of this latitude. The presence of 21 brant so far south as Humboldt Bay in July and August is, therefore, most unusual, and the fact that a pair appears to have bred there is even more exceptional. There does not seem to be much reason to doubt that the young birds reported above were actually brant. Captain Churchill is reported to be a reliable observer who knows brant, as is Davis. Lahr's report that the young were covered with "yellowish" down, however, opens some reason for doubt, since the down of young brant is grayish or dark brown in color; however, in fairly large young such as he described, the down might be sun-bleached to appear yellowish. It would indeed be desirable to have one of these young birds collected to fully substantiate this record, and perhaps Davis will yet be successful in this. If not, we can at least state that the evidence is very strong that a pair of wild brant actually bred on Humboldt Bay in the summer of 1940.

Summary

In point of total numbers, the 1940 brant census of 75,412 birds is the second largest of nine consecutive annual counts and is exceeded only by that of 1935 when 125,153 brant were reported. As usual, the count at Humboldt, our largest brant bay, is responsible for the size of the total, as it also was in 1935. Elsewhere in 1940, larger than usual numbers of brant were reported from Drake's and Mission bays, which latter locality produced the largest census on record for the area. Morro Bay also held larger than average numbers of brant in 1940, though many fewer birds than were reported in the record count of 1939. Bodega Bay showed a slight decline over the previous census and a total considerably less than average. Tomales Bay was also considerably below average, although two smaller totals have been recorded for the area.

Generally, the census reveals a most satisfactory status for our black brant which appear to be increasing in numbers. This condition is not at all surprising in view of the extreme regulations which have for several years restricted gunning for these birds. Since 1937, we have had virtually a closed season on brant in California, amounting at the most to a few days' shooting at the very end of the gunning season at a few early arrivals; for in these years Federal restrictions have closed the shooting season before brant reached California waters in numbers. This year, with the open season extending to December 14, California brant shooters may look forward to two or three weeks of sport. It would have been much better for the brant gunners, however, and the writer also thinks better for waterfowl in California in general, if the 60-day season of 1940 could have been made two weeks later, as was originally rumored.

Another change in Federal regulations in 1940 over those in effect for several years that will favor early season duck shooters but will be unfavorable to brant gunners is the change of the time for commencing daily shooting from 7 a.m. to sunrise this year. Brant seldom arrive on California bays in shootable numbers before November 25. By that date the sun in this latitude does not rise in the central part of the state until 7 a.m. and not until nearly 7.20 a.m. by the close of the season on December 14. It rises even later by about 14 minutes at Humboldt Bay and correspondingly earlier at Morro Bay. Thus, instead of being able to shoot legally at 7 a.m., brant shooters will have to wait up to half an hour later, depending upon the date and locality. Since the best shooting is usually obtained early in the morning, this will work a hardship in many cases. Permitting shooting one-half hour before sunrise would be much more satisfactory to our brant gunners.

Lastly, what appears to the writer to be an unjustifiable further restriction upon brant gunners, has this season been imposed by the Federal Government in the reduction of the daily bag limit to three geese. The reason for this reduction is rendered more obscure by the fact that in 1937 and 1938 the daily limit on brant and other geese was raised to five, having been four for a number of years previous. No known reduction in numbers of geese or brant has occurred since 1936; in fact, the Government's own reports claim increases. Further,

the kill of black brant in the United States has been almost negligible during the past three years. Brant shooting is hard and sporty work. Success depends in great measure upon a combination of tidal and weather conditions, which may occur but once or twice in our present short season. The gunner should legally be permitted to gather a fair bag when such rare conditions offer, especially when all indications point to increased numbers of the birds. Three brant, which are little larger than mallard ducks, can scarcely be considered a fair day's bag. The writer believes that the daily limit could be raised to six or eight birds, the season lengthened, and shooting permitted earlier in the morning without producing an excessive kill. But the brant shooters, because of the hard work and many disappointments that this sport provides, are decidedly in the minority and the seasons and limits are fixed for other kinds of waterfowl, so there does not appear to be much hope that the brant gunners will get a better deal in the future.

BLACK BRANT ON SAN QUENTIN BAY, LOWER CALIFORNIA[1]

By OLIVER B. COPE
Stanford University

San Quentin Bay, situated on the west coast of Lower California, 180 miles south of San Diego, California, was visited on March 25 and 26, 1940, by students from the Natural History Museum of Stanford University. On the morning of March 26, the opportunity was taken to organize a survey of the black brant (*Branta bernicla nigricans*) occurring on the northern arms of the bay. The data gathered are here presented with the hope that they may be of value in supplementing the annual brant census conducted under the direction of James Moffitt of the California Academy of Sciences, in cooperation with the California Division of Fish and Game, and that they may serve as a comparison with the only other complete count recorded from the same area, made by Donald H. Fry, Jr., of the Division of Fish and Game, on March 28, 1938. An estimate made on February 10,

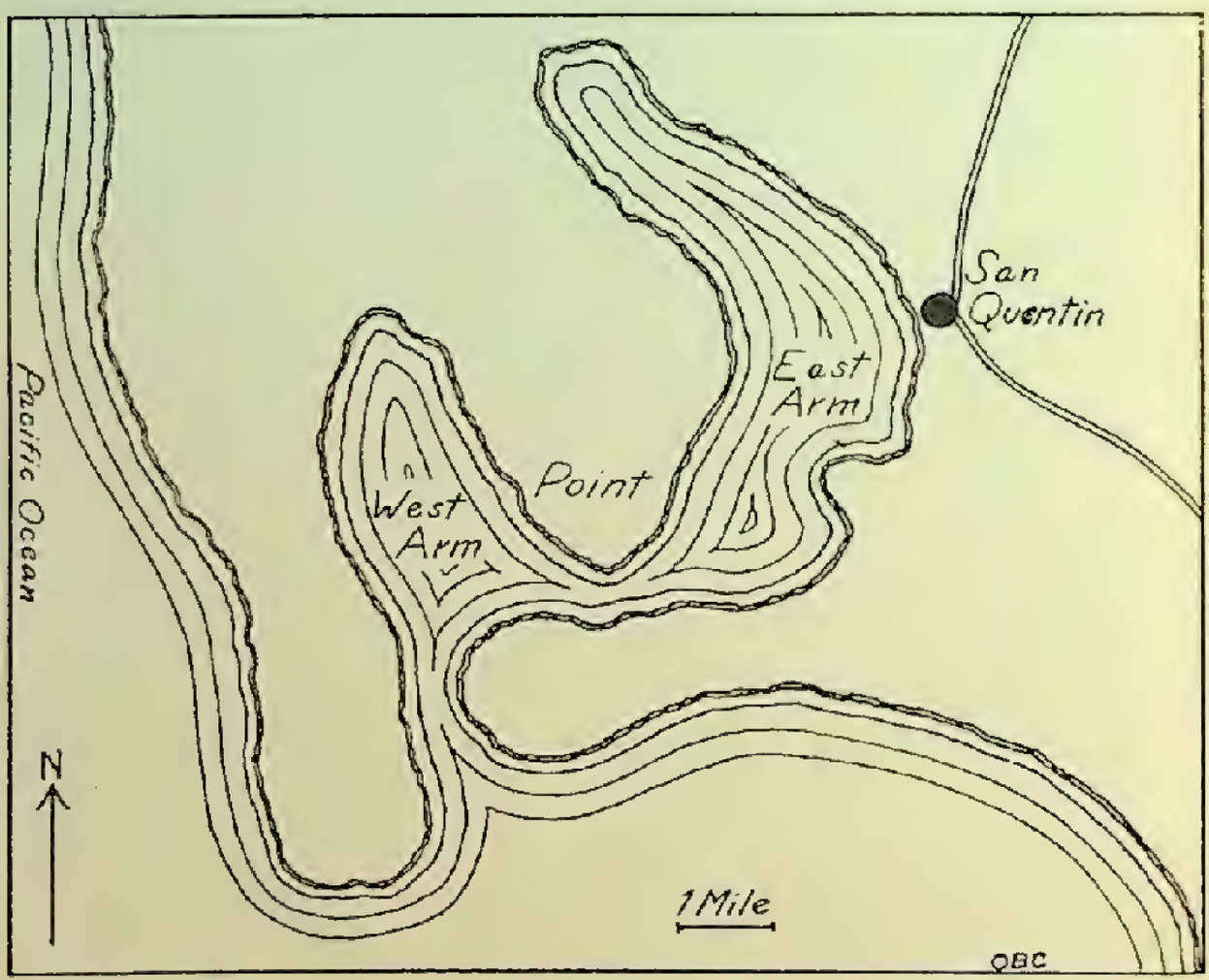

FIG. 137. Map of San Quentin Bay, Lower California, showing relationships of east and west arms of the bay.

[1] Submitted for publication, April, 1940.

1935, showed that approximately 2000 brant were present at that time (Moffitt, 1935).

Limitations in time prevented the counting of the complete bay area and the adjacent open sea, which is also known to harbor the birds during March. The two northern arms of the bay were searched completely from the shores by having each of three groups of survey members count the number of birds along a definite length of shore line. Care was taken to eliminate the possibilities of duplicate counting of the same birds by different parties, and it is felt that some success was had in this attempt. The counting was not complicated too much by flights of small flocks of brant; it was fairly easy to keep an accurate accounting of such movements.

The eastern arm of the bay harbored one large flock of brant at the extreme northern end, in addition to a widely diffused array which was scattered upon the waters in the southern portion. Floating fragments of eel grass were fairly abundant and were probably the attraction to the swimming birds. As the surface of the water grew rougher near the end of the morning, it was noticed that the brant in the southern bay area were moving to join the flock at the northern end of the bay. At noon, the augmented gathering at the northern end could be seen feeding on the herbage on the shore, while few birds could be noted on the water. Whether it was the choppy water or the lack of floating food that caused the brant to move up onto the shores was not determined. The total number of black brant counted on the eastern arm of the bay was 1175. A search for other game birds revealed the presence of about 20 canvasbacks, *Nyroca valisineria*.

In the limited time available, the western arm of San Quentin Bay was not as easily accessible from the base camp. Consequently, a complete count could not be made. An accurate summation was recorded on the southern portion of this arm of the bay, in the vicinity of the point, but it was necessary to estimate the numbers of brant in the northern area, near the salt works. There were 185 black brant counted, and an additional 500 estimated in the western arm.

A comparison with Fry's 1938 count in the same areas follows:

	March 20, 1938	March 26, 1940
Western Arm	850	685
Eastern Arm	535	1,175
Totals	1,385	1,860

It is realized that such a comparison is difficult, due to fluctuations in local time and weather conditions and short movements of flocks of brant. Fry's counts covered a wider area, including, in addition to the records noted in the above table, a tabulation of the brant in the ocean up to the dividing points of the arms of the lagoon and a count of the birds in the extreme northern end of the eastern arm. However, it can be noted that the 1938 and 1940 total counts for the same areas are in the same order of magnitude.

Moffitt (1939) has shown that the year's greatest concentration of black brant in California bays is reached in mid-March. The fact that these birds are present in such numbers in Lower California after this time, and the fact that numbers of black brant are later seen to

be flying past California bays toward the north, seem to indicate that the birds recorded at San Quentin Bay on March 26 must fly as far north as Oregon and Washington bays. Moffitt, in his annual reports on the black brant census in California, has given summaries of the habits and movements of these birds. Readers are referred to these reports, published in California Fish and Game, 1930-1939, for such information.

The author was assisted in making counts and keeping records by Betty Hammerly, Alice Rundle, Marion Theobald and John Poindexter, all of the Natural History Museum of Stanford University.

References

Fry, Donald H., Jr.

1938. Brant census of San Quentin Bay, Lower California. California Fish and Game, vol. 24, no. 4, pp. 347-349.

Moffitt, James

1935. Fifth annual black brant census in California. *Ibid.*, vol. 21, no. 4, pp. 343-350.

1939. Ninth annual black brant census in California. *Ibid.*, vol. 25, no. 4, pp. 336-342.

EDITORIALS AND NOTES

TWENTY-FIVE YEARS AGO IN "CALIFORNIA FISH AND GAME"

Of considerable interest is the note in the October, 1915 issue of "California Fish and Game" to the effect that the 1914 kill of deer in California amounted to something over 12,000. In those days there were no deer tags to furnish fairly complete reports, and the 12,000 deer represent field counts and estimates by game wardens and forest rangers. In 1914, Trinity County led the State with 735 deer actually reported, Monterey was second with 632, and Siskiyou third with 575. Although the 1914 estimated kill is probably below the actual kill, it is still significantly less than the reported total kill of 43,251 in 1939.

An editorial appearing in the 1915 issue has a familiar ring in these days of widespread warfare. It begins with, "The present European war has stirred up a great deal of sentiment favoring preparedness. In the discussions as to means of providing a trained army are to be found many references to the potential power available in the army of hunters." What was true then still holds today. A nation of outdoorsmen, familiar with the use of firearms and inured to life in the open, is better prepared to maintain its freedom than a country where men are prohibited the possession and use of firearms.

An article by N. B. Scofield relates the successful control of marsh mosquitoes by the use of small carnivorous fish instead of by ruining the marshes with a coating of oil. Even today, oil is still used in some places and could well be replaced by the breeding and planting of mosquito fish and sticklebacks. Our marshes could be saved for the waterfowl and other wildlife and become places of beauty by the application of common sense instead of oil, or what is even worse—draining them. As with mosquito control, so with other things pertaining to wildlife; let's find out the best way to do a job—instead of going ahead with the old-fashioned way.—*Richard S. Croker, Editor, California Fish and Game.*

A CURIOUS MUTATION IN A COYOTE FROM KERN COUNTY, CALIFORNIA

A male coyote (*Canis latrans*) of unusual appearance was trapped March 25, 1940, by Jack Sawyer, two miles east of Lebec, Kern County, California. This animal was brought to the California Museum of Vertebrate Zoology by J. R. Wallace, Supervisor of State trappers of the California Division of Fish and Game, who recognized the peculiarities of the animal as comprised in the unusually short legs. (See Fig. 138A.)

When the animal was prepared as a museum study specimen, including a complete skeleton, it was ascertained that the animal was normal in all respects save for the shortening of the legs. All parts

of the legs were shorter than in a normal coyote and the total length of the legs was about two-thirds that of an ordinary individual. This is shown by comparing figure 138A with figure 138B. Figure B is of a male coyote comparable in age to that shown in figure A, but with

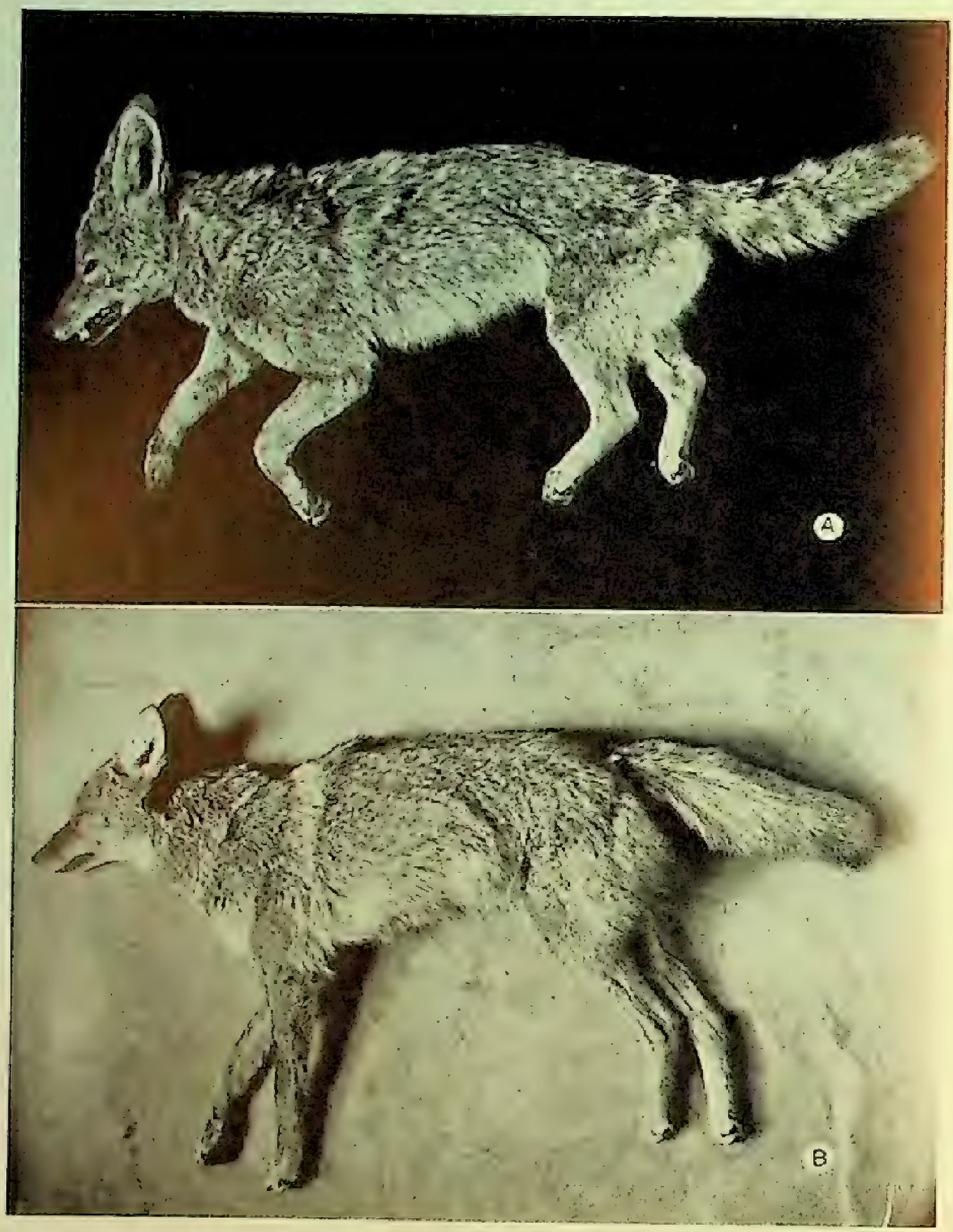

FIG. 138. A is an adult male coyote, MVZ No. 90685, from two miles east of Lebec, Kern County, California. Short legs. x 1/12.

B is an adult male coyote, MVZ No. 21545, from Yosemite Valley, Mariposa County, California. To show normal length of legs. Photo by C. D. Holliger. x 1/10.

legs of normal length. The animal was taken December 31, 1914, by Joseph Grinnell in Yosemite Valley, Mariposa County, California.

The shortened condition of the limbs and a slightly greater curvature of the bones near their ends permit one to designate the abnormality as chondroplasia. The exact reason for the appearance of this condition is not known but has currently been assumed to result from a temporary disharmony in the glands of internal secretion. In some breeds of domestic animals notable for short legs, this condition is known to be heritable. In some domestic animals the condition has appeared all at once. Because of its sudden appearance and heritable nature, the condition is spoken of properly as a mutation. The short-legged animal from Kern County was a fully adult male and if it had sired offspring it is reasonable to expect that other coyotes with similarly short legs may be found in southern Kern County. Among the breeds of domestic dogs, this coyote corresponds to the Dachshund, in the legs of which shortening has been carried to an even greater degree than in this coyote. The Dachshund, like this coyote, is normal in proportions of its skull and all parts of the skeleton except the bones of the legs.—*E. Raymond Hall, University of California, Museum of Vertebrate Zoology, June 20, 1940.*

CAPTURE OF A COATI *(NASUA NARICA)* IN SAN DIEGO COUNTY, CALIFORNIA

The coati, a mammal native to Mexico and Central America, is a member of the raccoon family, but its longer body, long tail and more pointed snout are some of the differential features which distinguish it from the raccoon. The animal has interest to residents of the Southwest because it has, within the memory of man, extended its geographic range northward into New Mexico and seemingly into Arizona. Therefore it seems worth recording the capture of a specimen (MVZ No. 90606, male) in the summer of 1939, by Bill Dye in Marrone Valley, San Diego County, along the border of Lower California. The skin and skull of this individual, now in the California Museum of Vertebrate Zoology, were placed there by J. R. Wallace, supervisor of State trappers of the California Division of Fish and Game.

It is the writer's opinion that probably this coati was an individual that escaped from captivity in the region where it was found. Nevertheless, it is possible that this kind of animal is extending its range farther westward than has heretofore been supposed, and sportsmen and others are urged to save any additional individuals of this animal, to the end that we may know more definitely about its occurrence.—*E. Raymond Hall, University of California, Museum of Vertebrate Zoology, June 20, 1940.*

GOLDEN SHINER REPORTED IN SHASTA AREA

Two specimens of *Notemigonus crysoleucas auratus* (Mitchill), the western golden shiner, have been turned over to me by J. H. Wales, fisheries biologist of the California Division of Fish and Game at Mt. Shasta. They were collected from Castle Lake in Siskiyou County at an elevation of 5200 feet. There is only one small school

of them in the lake at one end in a sheltered cove, where they seek shelter from the large trout under some logs. Wales says he knows of no other lake in the vicinity where they are to be found.

There are four subspecies of this fish, native only to the region east of the Rockies. These fish are widely used by black bass culturists as forage fish. They were used for a time in the Elk Grove Hatchery but were abandoned in favor of native minnows. All four subspecies are apparently used without discrimination under the name of "golden shiner" by the fish culturists.

The only other recorded instance of the introduction of this fish into California is by Carl L. Hubbs of the University of Michigan, who reports them in the streams around San Diego. There are three possible ways in which the golden shiner could have been introduced into Castle Lake. First, it may have been brought up from around San Diego or Elk Grove with a shipment of game fish, but this seems unlikely because trout alone are planted in this lake. Second, it may have come west with some eastern trout. Wales, however, knows of no planting that could have introduced them. Third, fishermen may have brought it in as bait, and dumped what they did not use into the lake. This is unlikely, though, unless they are more widely distributed than is known at present. No fisherman would be likely to bring live minnows from San Diego or Elk Grove. Also, they are very scarce in the latter location. Hubbs verified the identification and assigned the subspecies.—*Garth Murphy, Sacramento Junior College, June, 1940.*

DISTRIBUTIONAL NOTE ON THE EUROPEAN TENCH

Tinca tinca

The European tench has recently been collected from one of the Mud Lakes, which are in San Mateo County in the eastern foothills of the Santa Cruz Mountains, about twelve miles from Stanford University. These lakes are a series (four) of enlarged sag ponds, the one in question lying on the property of W. A. Mariani.

According to Dill and Shapovalov (California Fish and Game, vol. 25, no. 4, pp. 313-324, 1939), this fish is "Not yet an inhabitant of our natural waters, but present in ponds near Half Moon Bay * * *." W. A. Mariani states that the original stock in his lake was "brought from a pool near Half Moon Bay about six years ago."

In regard to this fish, Dill and Shapovalov further state that "Its tenacity of life in the presence of little oxygen is in itself remarkable." This is of particular interest in this case for the surface of Mud Lake is covered by duckweed fern (*Azolla filiculoides*), which considerably lowers the dissolved oxygen content of the water. In fact, an average of the two samples tested showed 6.16 parts of oxygen per million as contrasted with samples from a nearby open water lake (Searsville Lake) which averaged 13.17 parts per million of dissolved oxygen.—*J. C. Marr, Stanford University, July 3, 1940.*

NOTE ON THE NORTHERN GREEN ABALONE

Haliotis walallensis Stearns

In an attempt to identify some small abalones, it was discovered that the original series of specimens from which the northern green abalone, *Haliotis walallensis* Stearns, was described included specimens of the red abalone, *H. rufescens*, and questionably some of the black abalone, *H. cracherodii*. In order to correct the confusion this situation has caused, we designate as the lectotype of *H. walallensis* Stearns, 1899, specimen number 12573 in the collections of the Museum of Paleontology, at the University of California. This specimen is the one figured by Oldroyd (1927) as *H. rufescens*. The other specimens of the original series described by Stearns are in the University of California and in the U. S. National Museum collections.

The northern green abalone has recently been taken off Pt. Estero, San Luis Obispo County, California, in 5 to 12 fathoms of water by Delmar Reveia, a commercial abalone diver. This is one hundred miles south of any previous record.

References

Oldroyd, Ida Shepard

1927. The marine shells of the west coast of North America. Stanford University Publications. University Series., Geological Sciences, vol. 2, pt. 3, pl. 89, fig. 2; pl. 90, fig. 2.

Stearns, R. E. C.

1899. Preliminary description of a new variety of *Haliotis*. Nautilus, vol. 12, no. 9, pp. 106-107.

Howard McCully, California State Fisheries Laboratory, Division of Fish and Game, July 8, 1940.

REPORTS

STATEMENT OF REVENUE

For the Period July 1, 1939, to June 30, 1940, of the 91st Fiscal Year

	Detail	Subtotal	Total
Revenue for Fish and Game Preservation Fund:			
License Revenue—			
1940 series:			
Angling—			
Citizen	$278,966 00		
Less sales refunded to ineligible licensees	—8 00		
Net citizen	$278,958 00		
Nonresident	2,388 00		
Alien	9,415 00		
Duplicate	162 00		
Total angling		$290,923 00	
Hunting—			
Citizen	$64 00		
Junior	10 00		
Declarant alien	20 00		
Total hunting		$94 00	
Trapping, citizen		1 00	
Fish packers and wholesale shell fish dealers		110 00	
Deer tags		6 00	
Fish tags		1,899 70	
Game tags		121 05	
Market fishermen		48,450 00	
Fish importers		80 00	
Fishing party boat permits		430 00	
Fish breeders		405 00	
Game breeders		1,327 50	
Kelp licenses		30 00	
Total, 1940 series			$341,037 31
1939 series:			
Angling—			
Citizen	$435,652 00		
Less sales refunded to ineligible licensees	—34 00		
Net citizen	$435,618 00		
Nonresident	6,159 00		
Alien	7,005 00		
Duplicate	680 50		
Total angling		$449,459 50	
Commercial hunting club, citizen		850 00	
Commercial hunting club operator—			
Citizen	$295 00		
Alien	25 00		
Total commercial hunting club operator		$320 00	
Deer tags	$151,589 00		
Less sales refunded to ineligible licensees	—2 00		
Net total deer tags		$151,587 00	
Fish breeders		45 00	
Fish importers		10 00	
Fish packers and wholesale shell fish dealers, citizens	$1,115 00		
Less sales refunded to ineligible licensees	—5 00		
Net fish packers and wholesale shell fish dealers, citizen	$1,110 00		
Aliens	40 00		
Total fish packers and wholesale shell fish dealers		$1,150 00	
Fishing party boat permits		193 00	
Fish tags		1,851 48	
Game tags		465 54	
Game breeders		160 00	
Hunting—			
Citizen	$474,272 00		
Less sales refunded to ineligible licensees	—10 00		
Net citizen	$474,262 00		

STATEMENT OF REVENUE—Continued

For the Period July 1, 1939, to June 30, 1940, of the 91st Fiscal Year

	Detail	Subtotal	Total
Revenue for Fish and Game Preservation Fund—Continued:			
License Revenue—Continued—			
1939 series—Continued:			
Hunting—Continued—			
Junior	$20,329 00		
Nonresident	13,870 00		
Declarant alien	2,800 00		
Alien	1,500 00		
Duplicate	900 00		
Total hunting		$519,661 00	
Market fishermen	$42,360 00		
Less sales refunded to ineligible licensees	—30 00		
Net total market fishermen		$42,330 00	
Trapping—			
Citizen	$1,934 00		
Alien	40 00		
Total trapping		$1,974 00	
Total, 1939 series			$1,170,056 52
1938 series:			
Angling—			
Citizen	$7,726 51		
Alien	90 00		
Nonresident	33 00		
Duplicate	5 00		
Total angling		$7,854 51	
Deer tags		2,653 00	
Hunting—			
Citizen	$16,652 00		
Less sales refunded to ineligible licensees	—2 00		
Net citizen	$16,650 00		
Junior	1,103 00		
Duplicate	43 00		
Total hunting		$17,796 00	
Market fishermen		2,400 00	
Trapping, citizen		145 00	
Total, 1938 series			$30,848 51
1937 series:			
Angling—			
Citizen	$110,986 03		
Alien	2,505 00		
Duplicate	130 00		
Nonresident	1,644 00		
Total angling		$115,265 03	
Commercial hunting club		50 00	
Commercial hunting club operator		10 00	
Deer tags		11,437 00	
Fish breeders		15 00	
Game breeders		5 00	
Hunting—			
Citizen	$40,128 97		
Junior	2,455 00		
Alien	150 00		
Duplicate	57 50		
Nonresident	800 00		
Declarant alien	220 00		
Total hunting		$43,811 47	
Market fishermen		180 00	
Trapping, citizen		341 00	
Total, 1937 series			$171,114 50
1932 series, hunting		$87 35	
1928 series, angling		645 68	
1928 series, deer tags		10 00	
1928 series, hunting		2,971 00	
Total, 1928 and 1932 series			$3,714 03

STATEMENT OF REVENUE—Continued

For the Period July 1, 1939, to June 30, 1940, of the 91st Fiscal Year

	Detail	Subtotal	Total
Revenue for Fish and Game Preservation Fund—Continued:			
Other revenue:			
Court fines		$42,518 03	
Deer meat permits		900 00	
Fish packers		344,015 64	
Kelp tax revenue		356 19	
Leases game refuges		828 96	
Lease of kelp beds		1,334 50	
Miscellaneous revenue		9,807 06	
Publication sales		259 71	
Salmon packers tax		19,263 98	
Total other revenue			$419,284 07
Total current year			$2,130,054 94
Prior year, 90th—			
1938 series:			
Angling—			
Citizen	—$35 00		
Duplicate	6 00		
Nonresident	8 00		
Alien	15 00		
Total angling		—$6 00	
Fish importers		—5 00	
Fish packers and wholesale shell fish dealers		35 00	
Hunting—			
Citizen	—$16 00		
Duplicate	1 50		
Junior	20 00		
Nonresident	30 00		
Total hunting		$35 50	
Trapping, citizen		—2 00	
Total prior year, 1938 series			$57 50
1937 series:			
Hunting—			
Citizen	—$18 00		
Junior	—17 00		
Total hunting		—$35 00	
Trapping, citizen		1 00	
Fish packers and shell fish dealers		—30 00	
Total prior year, 1937 series			—$64 00
89th fiscal year—			
1938 series:			
Angling—			
Citizen	—$519 50		
Alien	685 00		
Duplicate	—6 50		
Nonresident	—39 00		
Total angling		$120 00	
Fish importers		5 00	
Fish packers and wholesale shell fish dealers		—5 00	
Fish tags		—1,767 24	
Game tags		—161 34	
Hunting—			
Citizen	—$18 00		
Junior	—18 00		
Total hunting		—$36 00	
Market fishermen		420 00	
Total prior year, 1938 series			—$1,424 58

STATEMENT OF REVENUE—Continued

For the Period July 1, 1939, to June 30, 1940, of the 91st Fiscal Year

	Detail	Subtotal	Total
Revenue for Fish and Game Preservation Fund—Continued:			
89th fiscal year—Continued—			
1937 series:			
Angling—			
Citizen	$370 00		
Nonresident	39 00		
Alien	—550 00		
Total angling		—$141 00	
Deer tags		—3 00	
Game tags		161 34	
Fish tags		1,707 24	
Hunting—			
Citizen	—$11 00		
Junior	12 00		
Total hunting		$1 00	
Market fishermen		—120 00	
Trapping, citizen		—2 00	
Total prior year, 1937 series, 89th			$1,363 58
Refund on fish packers tax, 90th prior year			—140 25
Grand total all years, Fish and Game Preservation Fund			$2,130,747 19

STATEMENT OF EXPENDITURES

For the Period July 1, 1939, to June 30, 1940, of the Ninety-first Fiscal Year

Function	Salaries and wages	Materials and supplies	Service and expense	Property and equipment	Total
Administration:					
Cashier	$1,040 00				$1,040 00
Education and public information	498 16	$1 81	$82 35		582 32
Executive	4,999 92	309 36	5,499 47	$66 07	10,874 82
Exhibits			1,253 01		1,253 01
General office	7,833 07	8,075 43	46,851 12	1,057 60	63,817 22
Library	2,033 02	41 21	145 57	278 25	2,498 05
Property inspection	3,270 00	140 24	225 68	87 19	3,729 11
Publicity			1,464 84		1,464 84
Total Administration	$20,274 17	$8,574 05	$55,522 04	$1,489 11	$85,859 37
Patrol and Law Enforcement:					
Cannery inspection	$25,105 90	$650 53	$2,850 34		$28,615 77
Executive	16,800 00	525 13	2,300 85	$532 81	20,158 79
General office	6,220 62	1,059 31	797 98	269 83	8,356 74
Junior patrol	4,473 44	779 08	1,740 73	3 42	6,996 67
Land patrol	222,025 21	36,850 22	63,253 78	19,058 29	341,187 50
Marine patrol	84,340 63	22,015 84	55,701 86	17,697 65	179,755 98
My—Bluefin Galley		450 64			450 64
My—N.B. Scofield Galley		—99 86			—99 86
Pollution patrol	12,088 91	2,556 60	4,097 57	2,246 58	20,989 66
Total Patrol and Law Enforcement	$371,063 71	$64,796 49	$130,743 11	$39,808 58	$606,411 89
Marine Fisheries:					
Central Valley Water Project study	$7,403 89	$1,084 36	$3,622 52	$4 36	$12,115 13
Executive	5,380 00	196 25	328 62		5,904 87
Field supervision	6,405 00	298 72	1,015 12		7,718 84
Fish cannery auditing			4,493 70		4,493 70
General office	11,710 92	676 56	833 18	534 56	13,761 22
Research and statistics	50,663 23	4,608 15	10,656 25	2,467 59	68,395 22
Total Marine Fisheries	$81,560 04	$6,864 04	$20,949 30	$3,006 51	$112,388 98
Fish Conservation:					
Biological survey	$12,254 00	$1,071 99	$1,313 13	$624 35	$15,263 47
Executive	7,105 24	191 27	673 77		7,970 28
Field supervision	4,410 00	506 61	899 51	371 47	6,187 59
Fish food unallocated		6,870 18	3,484 00		10,354 18
Fish planting	4,185 17	789 58	1,745 90	1,691 46	8,412 11
Fish rescue	10,582 95	1,052 99	2,207 09	498 43	14,341 46
General office	5,501 00	1,185 50	146 71	147 27	6,981 38
Pollution inspection	5,079 00	499 48	943 51	139 43	6,661 42
Statistical	2,475 00	315 08	2,111 28		4,901 36
Structural maintenance	4,360 63	507 39	1,686 07	57 43	6,612 12
Alpine Hatchery	1,902 40	539 06	175 17		2,616 63
Arrowhead Lake Egg Collecting Station	604 67	105 73	59 85	29 90	800 15
Basin Creek Hatchery	4,879 58	1,096 85	441 31	59 81	6,477 55
Bear Lake Egg Collecting Station		1 18			1 18
Benbow Dam Experimental Station	2,683 05	184 92	152 39	4 88	3,025 24
Big Creek Hatchery	1,862 50	399 15	305 65	9 44	2,576 74
Blue Lakes Egg Collecting Station	563 29	7 63	27 36		598 28
Bogus Creek Egg Collecting Station	813 01	84 22	125 72		1,022 95
Brookdale Hatchery	4,000 93	803 45	355 04	486 30	5,645 72
Burney Creek Hatchery	6,322 29	1,240 90	394 81	60 66	8,018 66
Central Valleys Hatchery	2,965 00	1,234 00	1,467 09	593 57	6,259 66
Cold Creek Hatchery			10 00		10 00
Copco Egg Collecting Station		33 14	85 64	9 84	128 62
Cottonwood Lakes Egg Collecting Station	292 00		51 00		343 00
Experimental Hatchery	1,836 45	108 61	30 40		1,975 46
Fall Creek Hatchery	6,986 14	2,916 98	345 18	700 54	10,948 84
Feather River Hatchery	5,175 07	1,377 78	625 55	516 87	7,695 27
Fern Creek Hatchery	1,771 46	231 93	299 04		2,302 43
Fillmore Experimental Station	135 00	117 36		89 34	341 70
Fishing Creek Experimental Station			150 00		150 00
Forest Home Hatchery	4,850 33	6,247 61	1,289 95	1,108 20	13,496 09
Fort Seward Hatchery	4,020 19	732 61	156 87	8 68	4,918 35
Heenan Lake Egg Collecting Station		122 16	2 71	30 08	154 95
Hot Creek Hatchery	5,208 97	6,114 33	1,008 88	629 11	12,961 29
Huntington Lake Hatchery	1,710 66	629 03	317 70		2,657 39
June Lake Egg Collecting Station			16 30		16 30
Kaweah Hatchery	5,112 31	1,601 03	1,019 53	24 84	7,757 71
Kernville Rearing ponds		18 53	113 90	3 70	136 13
King Salmon Experimental Station			11 08		11 08
Kings River Hatchery	5,764 50	3,533 08	515 87	1,195 03	11,008 48
Kirman Lake Egg Collecting Station	283 75	6 62			290 37

STATEMENT OF EXPENDITURES

For the Period July 1, 1939, to June 30, 1940, of the Ninety-first Fiscal Year—Continued

Function	Salaries and wages	Materials and supplies	Service and expense	Property and equipment	Total
Fish Conservation—Continued:					
Klamathon Egg Collecting Station	$1,497 13	$125 82	$48 15	$90 13	$1,761 23
Lake Almanor Hatchery	6,373 55	2,166 03	830 48	8 86	9,381 92
Lake Eleanor Egg Collecting Station	198 71	18 60	50 00		267 31
Little River Egg Collecting Station	360 00	21 90	12 60		394 50
Little Walker Lake Egg Collecting Station	252 27	9 82			262 09
Lytle Creek Hatchery	21 85	5 70	28 30		55 85
Mad River Egg Collecting Station	680 00	52 03	20 25		752 28
Madera Hatchery	1,846 94	900 94	366 10		3,113 98
Marlette Lake Egg Collecting Station	360 00	89			360 89
Mt. Shasta Hatchery	39,023 79	14,726 99	2,781 86	907 92	57,440 56
Mt. Tallac Hatchery	2,933 43	2,579 12	231 58	678 51	6,422 04
Mt. Whitney Hatchery	13,370 87	2,723 44	2,155 18	1,191 07	19,470 56
Mountain Home Hatchery	4,840 00	3,358 47	2,087 20		10,285 67
Prairie Creek Hatchery	5,478 31	1,519 78	618 88	552 11	8,169 08
Rush Creek Egg Collecting Station	640 00	9 51	18 48		668 02
San Lorenzo Egg Collecting Station		84 96	1 00		85 96
Scott Creek Egg Collecting Station	1,740 00	165 41	82 68	3 10	1,991 19
Shackleford Creek Egg Collecting Station	420 00	8 14	50 00		478 14
Shasta River Egg Collecting Station	925 20	69 21	128 69		1,123 10
Snow Mountain Egg Collecting Station	2,072 26	138 60	62 28	317 08	2,590 22
Tahoe Hatchery	6,355 51	1,829 49	532 99	3 24	8,721 23
Upper Truckee Egg Collecting Station	271 93		10 00		281 93
Waddell Creek Station	1,260 00	39 03	44 12	2 73	1,345 88
Yosemite Hatchery	5,129 76	1,374 82	339 49	76 89	6,920 96
Yuba River Hatchery	3,659 19	873 61	220 51	350 99	5,104 30
Total Fish Conservation	$225,400 01	$75,280 30	$35,522 38	$13,273 26	$349,481 98
Hydraulics:					
Engineering	$8,404 85	$1,020 39	$1,999 79	$226 33	$11,651 36
Executive	4,320 00	290 61	861 43		5,472 04
Fish screens		19 45		20 60	40 05
General office	1,415 00	119 09	258 21	100 50	1,892 60
Total Hydraulics	$14,139 85	$1,449 54	$3,119 43	$347 43	$19,056 25
Game Conservation:					
Deer damage control	$281 86	$136 63	$181 84		$600 33
Duck rescue	739 82	294 67	644 26	$337 10	2,015 85
Elk Refuge	1,770 00	427 88	370 56		2,568 44
Executive	9,085 32	1,033 06	2,205 09	459 77	12,786 24
Game management	9,189 84	1,723 60	1,808 96	879 81	13,001 61
General office	3,255 00	211 21	12 58	107 36	3,646 15
Grey Lodge Refuge	4,945 74	909 32	200 99	1,135 05	7,191 10
Imperial Refuge	2,485 11	329 72	151 36	373 75	3,339 94
Los Banos Refuge	4,684 11	811 48	578 47	575 98	6,650 04
Predatory Animal—Lion hunting	6,185 00	946 21	7,092 92	1,416 32	15,640 45
Predatory animal—Trapping	29,948 36	6,101 92	6,003 01	2,391 76	44,445 05
Refuge posting		345 57			345 57
Research	8,178 72	1,965 98	3,177 07	1,686 39	15,008 16
Statistics	2,400 00	161 35	1,302 41		3,863 76
Suisun Refuge	4,197 00	499 94	553 13	709 29	5,959 36
Winter feeding and salting of game		324 94			324 94
Total Game Conservation	$87,345 88	$16,222 88	$24,285 68	$10,132 58	$137,987 02
Game Farms:					
Executive	$3,480 00	$103 31	$1,075 91	$155 49	$4,814 71
Game Bird Distribution:					
Los Serranos	$154 00	$469 68	$132 14		$755 82
Yountville	6,854 69	2,540 22	2,341 89	$561 35	12,298 15
General office	1,069 03		100 00	15 45	1,184 48
Los Serranos Boarding House			118 17		118 17
Los Serranos Game Farm	12,628 64	3,300 73	1,694 61	107 31	17,731 29
Yountville Boarding House	734 81	877 23	176 53		1,788 57
Yountville Game Farm	12,737 61	5,715 37	2,161 51	722 21	21,336 70
Total Game Farms	$37,658 78	$13,006 54	$7,801 06	$1,561 81	$60,028 19
Licenses:					
Executive	$3,355 00	$223 84	$399 99		$3,978 83
General office	1,149 10	434 00	1,039 39	$928 49	3,550 98
License distribution	14,371 86	12,403 54	69,384 97	702 68	96,863 35
Total licenses	$18,875 96	$13,061 68	$70,824 35	$1,631 17	$104,393 16

STATEMENT OF EXPENDITURES

For the Period July 1, 1939, to June 30, 1940, of the Ninety-first Fiscal Year—Continued

Function	Salaries and wages	Materials and supplies	Service and expense	Property and equipment	Total
Other Current Expenses:					
Maintenance and construction of fish screens and other stream improvements:					
Fish screens—All objects					$41,333 51
Stream Improvements:					
American Lake check dam		$84 72			$84 72
American River Improvement Project		18 80			18 80
Granlees Dam Fishway Project	$1,173 32	1,076 41	$114 85	$2 46	2,367 04
Overhead		17 10	10 50	749 71	777 31
Removal of riffles on Lower Eel River			96 00		96 00
Sheep Camp Lake Project			20 00		20 00
Total Stream Improvements	$1,173 32	$1,197 03	$241 35	$752 17	$3,363 87
Total other current expenses					44,697 38
Total allotment from Support, 91st fiscal year					$1,520,307 22
Special item—					
Appropriation to pay claim of Department Accounting Officer, Department of Finance, 91st fiscal year, Ch. 1046–39					393 61
Total operating expenditures, 91st fiscal year					$1,520,700 83
Contributions to Employees' Retirement System, 91st fiscal year					27,061 65
Expenditures for additions and betterments—					
Purchases for game refuges and public shooting grounds and construction, improvement and equipment—all projects	$2,462 19	$10,900 40	$3,105 30	$3,828 28	20,296 17
Special item—					
Game management cooperation with Federal Government—all projects, all objects					5,033 23
Total 91st fiscal year					$1,573,094 88
Prior biennium					(None)
Grand total Fish and Game					$1,573,094 88

GAME CASES

April, May, June, 1940

Offense	Number arrests	Fines	Jail sentences (days)
Deer: Deer meat, closed season, possession female deer, killing yearling, parts of deer closed season, spike buck, using light and gun, shooting a spotted fawn	65	$1,577 00	1,004½
Doves: Closed season	4	85 00	----------
Ducks: Closed season, shoot before 7 a.m.	6	235 00	----------
Firearms: Possess and discharge in Refuge 4B	4	40 00	----------
Geese: Wild, closed season	2	50 00	----------
Hunting: No license, night	26	445 00	55
Nongame birds: Possession and killing, possess seagull	3	20 00	----------
Pheasants: Closed season, sale, overlimit, take hen pheasants, no license, male pheasant, closed season	16	420 00	410
Plover: Possession	1	100 00	----------
Quail: Valley quail, closed season, shooting, no license, take with trap	8	200 00	----------
Rabbits: No license, brush rabbits closed season, shoot from motor vehicle, night hunting, possession cottontails	27	302 00	----------
Shooting from motor vehicle	4	30 00	----------
Squirrels: Possess tree squirrels	6	50 00	----------
Traps: Theft of No. 3 Victor traps	2	25 00	----------
Totals	174	$3,579 00	1,469½

FISH CASES

April, May, June, 1940

Offense	Number arrests	Fines	Jail sentences (days)
Abalones: Possess more than 10, undersized black, no license, overlimit	25	$455 00	35
Angling: No license, using another's license, closed season, at night, with more than 1 pole, in a fish refuge, closed district, overlimit game fish, within 150 ft. of lower side of dam or weir, in ponds controlled by the Commission	114	1,045 50	15½
Angling license: Make false statement to obtain, fail to show on demand	10	131 00	13½
Bass: Possess black, closed season, striped bass at night, no license, using more than 3 hooks fishing for striped bass, trolling for striped bass with 2 lures, overlimit calico bass, selling striped bass	110	1,580 00	230
Catfish: Overlimit, closed season, take other than by angling, undersized	6	100 00	
Clams: Overlimit Washington, possess clam forks in State Clam Preserve 18-A, cockle clams, no license, possess undersized Pismo clams, clams in clam preserve, undersized Pismos, possess out of shell, overlimit razor clams	57	680 00	347½
Commercial fishing: No license, fail to register boat and gear, fail to keep fish records	32	375 00	50
Crabs: Undersized	3	35 00	7
Crappie: Closed season	4	75 00	12½
Grunion: Closed season	4	40 00	
Halibut: Possess and sale of undersized	1		
Lobsters: Undersized, closed season	9	200 00	40
Nets: Operating set gill net in Dist. 12-B, set gill net in closed waters, possess in a boat, set gill net in Dist. 3, operating fyke nets, illegal use of round haul net to take bait in Dist. 41/8, gill net with meshes over 1¾ in., operate beach net in Dist. 1, using a lampara net in Dist. 4 1/8, using round haul net to take barracuda and yellowtail in closed season, diver net without floats or buoys, drag net in Dist. 10	32	980 00	10
Perch: Closed season, no license	3	20 00	
Pollution	16	2,650 00	
Salmon: Closed season, undersized king and silver salmon, no license, fail to show on demand	8	190 00	
Set line: Using to take striped bass, operating, angling for game fish with set line	6	390 00	12½
Spear: Possession within 300 ft. of a stream	1	25 00	
Sunfish: Bluegill, closed season, no license	35	545 50	26
Trap: Possess fish taken in fish trap, operate fish trap	3	50 00	
Trout: Snagging, take steelhead, closed season, with pitchfork, illegal possession steelhead, closed season, no license, take with set pole, closed stream, overlimit	51	1,018 00	10
Tuna: Possess yellowfin weighing less than 7½ lbs	1	100 00	
Totals	537	$10,094 00	820½

SEIZURES OF FISH AND GAME

April, May, June, 1940

Fish:	
Abalones	29
Abalones, black	31
Abalones, red	136
Barracuda	3
Bass, pounds	10
Bass, black	110
Bass, calico	29
Bass, striped	203
Catfish, pounds	50
Clams	258
Cockle	36
Horseneck	20
Pismo	652
Crabs	48
Crappie	20
Fyke nets	2
Grunion	120
Halibut	1
Lobster pots	20
Lobster receiver	1
Lobsters	187
Perch	25
Salmon, King and Silver, pounds	2,500
Salmon, Silver	1
Shad, pounds	400
Sturgeon, pounds	15
Sunfish	92
Sunfish, Bluegill	110
Traps, Bass	2
Traps, Lobster	60
Trout	147
Eastern Brook	75
Loch Leven	7
Mackinaw, pounds	18
Rainbow	123
Steelhead	115
Steelhead, pounds	1
Tuna, Bluefin	1
Tuna, Yellowfin, pounds	5,616
Yellowtail	16
Game:	
Bird net	1
Deer meat, pounds	814
Doves	10
Ducks	4
Geese	1
Pheasants	12
Quail	4
Rabbits	35
Squirrels, tree	2

COMMERCIAL FISH LANDINGS IN CALIFORNIA BY FISHING BOATS, APRIL, 1940

Compiled by the Division of Fish and Game, Bureau of Marine Fisheries

Species	California waters								Waters south international boundary		Total landings by fishing boats
	*Del Norte and Eureka Region	Sacramento Region	San Francisco Region	Monterey Region	Santa Barbara Region	Los Angeles Region	San Diego Region	Total pounds	Los Angeles Region	San Diego Region	
Anchovy			1,400	2,325		5,444		9,169			9,169
Barracuda					21,309	510,162	29,554	561,025		4,283	565,308
Cabezone			30	87				117			117
Cabrilla										14,833	14,833
Carp		1,914						1,914			1,914
Catfish		31,659						31,659			31,659
Cultus, Pacific	25,705		14,545	3,036				43,286			43,286
Flounder, Starry	14,976		17,428	14,185				46,589			46,589
Flying Fish						3,131		3,131			3,131
Grouper										12,845	12,845
Halibut, California	3,935		5,349	2,726	16,535	54,490	13,565	96,597		15,364	111,961
Halibut, Northern	94,775							94,775			94,775
Hardhead		4						4			4
Herring, Pacific	104			1,300				1,404			1,404
Kingfish			991	21,968		30,874	10	53,843			53,843
Mackerel, Horse				6,840		39		6,879			6,879
Mackerel, Pacific			330	21,641		3,006	14,313	43,193			43,193
Mullet							61	61			61
Perch	1,533		3,702	3,874	169	4,338		13,616			13,616
Pike		31						31			31
Pompano, California						136		136			136
Rock Bass					4,742	10,183	512	15,437		881	16,318
Rockfish	93,153		37,434	213,312	18,957	18,530	26,207	407,593		2,570	410,163
Sablefish	23,968		1,766	3,401		8,855		37,990			37,990
Salmon	53,117	111,284		123,966				288,367			288,367
Sand Dab	46,168		14,320	5,965		385		66,838			66,838
Sardine			19,700	180,330	1,535	1,605	400	203,570			203,570
Sculpin					115	7,706	3,915	11,826		62	11,888
Sea-bass, Black					2,064	4,910	411	7,385		10,143	17,528
Sea-bass, White			680	59	6,653	12,273	522	20,187		485	20,672
Shad		665,838	843					666,681			666,681
Shark	55		40,385	44	42,301	53,950	3,879	140,617		1,348	141,965
Sheepshead					3,868	2,576	162	6,606		201	6,807
Skate	6,020		4,725	2,092	2,815	1,547		18,399			18,399

Smelt	676		11,255	1,127	5,805	9,316	2,620	30,805			30,805
Sole	496,137		79,832	50,201	24,761	3,545	608	664,087			664,087
Split-tail		230						230			230
Tomcod			197					197			197
Tuna, Bluefin						436,475	266,537	703,012	205,883	320	909,215
Tuna, Bonito					153	49,568	22,413	72,134		1,368	73,502
Tuna, Skipjack									4,831,461	598,371	5,429,832
Tuna, Yellowfin						215		215	3,111,689	4,138,305	7,250,209
Turbot			8,195	3,955		9		12,159			12,159
Whitebait	18,367		3,612	134				22,113			22,113
Whitefish, Ocean					2,784	1,142		3,926		212	4,138
Yellowtail					232	20,880	24,651	45,763	43,389	83,404	172,556
Miscellaneous Fish	16,093		2,183	200	521	3,268		22,265			22,265
Crustacean:											
Crab	206,116		447,631	4,004				657,754			657,754
Crab, Rock						131		131			131
Shrimp			54,477	452				54,929			54,929
Mollusk:											
Abalone				42,575	42,625			85,200			85,200
Clam, Cockle			47			2,013		2,060			2,060
Clam, Gaper			360					360			360
Clam, Pismo				784	12,168			12,952			12,952
Clam, Soft-shell	62		3,985					4,047			4,047
Clam, Washington	2,197		152					2,349			2,349
Octopus	66		460	952				1,478			1,478
Oyster, Eastern			9,193					9,193			9,193
Oyster, Japanese			77,216					77,216			77,216
Oyster, Native	1,520		90					1,610			1,610
Squid				45,125		21,700		66,825			66,825
Total pounds	1,105,343	810,960	862,513	769,266	210,115	1,283,392	410,349	5,451,938	8,192,416	4,884,905	18,529,349

* The geographical regions of the State are as follows:
Del Norte and Eureka Region: Del Norte, Humboldt and Mendocino counties.
Sacramento Region: Sacramento and San Joaquin river systems with the delta areas, including Suisun Bay and Lake County.
San Francisco Region: Sonoma, Marin, San Francisco and San Mateo counties, including San Francisco and San Pablo bays.
Monterey Region: Santa Cruz and Monterey counties.
Santa Barbara Region: San Luis Obispo, Santa Barbara and Ventura counties.
Los Angeles Region: Los Angeles and Orange counties.
San Diego Region: San Diego and Imperial counties.
These tables are subject to slight revision due to belated supplemental items.

COMMERCIAL FISH LANDINGS IN CALIFORNIA BY FISHING BOATS, MAY, 1940

Compiled by the Division of Fish and Game, Bureau of Marine Fisheries

Species	California waters								Waters south international boundary		Total landings by fishing boats
	*Del Norte and Eureka Region	Sacramento Region	San Francisco Region	Monterey Region	Santa Barbara Region	Los Angeles Region	San Diego Region	Total pounds	Los Angeles Region	San Diego Region	
Anchovy			10,575	7,550		6,793		24,918			24,918
Barracuda					22,175	338,068	17,035	377,278		235	377,513
Cabezone			125	208				333			333
Cabrilla										25,615	25,615
Carp		244						244			244
Catfish		2,474						2,474			2,474
Cultus, Pacific	10,535		21,844	4,426	15	56		36,876		98	36,974
Flounder, Starry	5,400	104	57,052	5,903				68,459			68,459
Flying Fish						7,917		7,917			7,917
Grouper										36,468	36,468
Hake	950		4,633					5,583			5,583
Halibut, California	1,890		3,103	732	35,928	27,612	6,860	76,125		4,174	80,299
Halibut, Northern	45,528							45,528			45,528
Herring, Pacific			1,800	2,175				3,975			3,975
Kingfish			107	17,967	51	22,751		40,876			40,876
Mackerel, Horse				6,461		13,990		20,451			20,451
Mackerel, Pacific				6,858	2,208	90,890	18,080	118,036			118,036
Mullet							262	262			262
Perch				80	74	479		633			633
Pompano, California				5		53	17	75			75
Rock Bass					2,980	20,215	4,490	27,685		978	28,663
Rockfish	34,045		47,731	178,163	30,275	17,576	4,049	312,739		18,814	331,553
Sablefish	36,055		13,573	6,327		2,874		59,729			59,729
Salmon	443,166	400,893	146,670	141,606		17		1,132,352			1,132,352
Sand Dab	19,120		91,818	2,685		491		114,114			114,114
Sardine			60,550	96,685	203	9,500	1,493	174,431			174,431
Sculpin					111	11,374	3,434	14,919			14,919
Sea-bass, Black					780	4,365	948	6,093		2,826	8,919
Sea-bass, Short-fin							274	274			274
Sea-bass, White				109	883	11,054	1,249	14,195		851	15,046
Shad		983,402						983,402			983,402
Shark	15		37,099	175	243,239	104,630	13,677	398,835		407	399,242
Sheepshead					9	955	22	986			986
Skate	2,005		13,135	507	71	884	34	16,636			16,636

Smelt	70		12,151	1,137	8,611	5,733	2,441	30,473			30,473
Sole	182,371		456,907	17,036	23,326	2,082	45	681,767			681,767
Split-tail		427						427			427
Swordfish, Broadbill					9			9			9
Tomcod			45					45			45
Tuna, Bluefin					1,585	4,979,619	615,153	5,596,357	8,540	175,800	5,780,703
Tuna, Bonito				398		16,903	36,843	54,144			54,144
Tuna, Skipjack									2,907,987	475,982	3,443,969
Tuna, Yellowfin									6,992,352	5,942,097	12,934,449
Turbot			10,423	1,979				12,402			12,402
Whitebait	10,755		1,887	220				12,862			12,862
Whitefish, Ocean					1,522	1,052		2,574		149	2,723
Yellowtail					7	34,712	79,102	113,821	7,970	24,059	145,850
Miscellaneous Fish	6,760		5,561	70	1,910	4,751	30	22,001			22,001
Crustacean:											
Crab	233,142		358,076	1,740				593,558			593,558
Shrimp			68,230	249				68,479			68,479
Mollusk:											
Abalone				200,925	182,150			383,075			383,075
Clam, Cockle			60			1,424		1,484			1,484
Clam, Gaper			300					300			300
Clam, Pismo					12,651			12,651			12,651
Clam, Soft-shell			4,000					4,000			4,000
Clam, Washington	222		136					358			358
Octopus	12		930	2,458				3,409			3,409
Oyster, Eastern			6,140					6,140			6,140
Oyster, Japanese			46,303					46,303			46,303
Oyster, Native	1,000		1,755					3,358			3,358
Squid				1,219,185				1,219,185			1,219,185
Total pounds	1,035,441	1,387,544	1,492,334	1,924,319	570,503	5,739,720	805,544	12,955,705	9,976,855	6,708,553	29,641,113

* See footnote to table for April.

COMMERCIAL FISH LANDINGS IN CALIFORNIA BY FISHING BOATS, JUNE, 1940

Compiled by the Division of Fish and Game, Bureau of Marine Fisheries

Species	California waters								Oregon and Washington waters	Waters south international boundary		Total landings by fishing boats
	*Del Norte and Eureka Region	Sacramento Region	San Francisco Region	Monterey Region	Santa Barbara Region	Los Angeles Region	San Diego Region	Total pounds	Del Norte and Eureka Region	Los Angeles Region	San Diego Region	
Anchovy			500	600		3,995		5,095				5,095
Barracuda						319,464	51,739	371,203		75	114	371,392
Cabezone			235	35	114			384				384
Cabrilla										345		345
Carp		107						107				107
Catfish		2,280						2,280				2,280
Cultus, Pacific	11,411		10,727	3,666	82	270		26,156				26,156
Flounder, Starry	48,200		47,942	870				97,102				97,102
Flying fish						3,374		3,374				3,374
Grouper											804	804
Hake	250		2,000			11		3,221				3,221
Halibut, California			2,746	439	38,045	10,791	526	61,547			2,070	63,617
Halibut, Northern	52,807				20			52,827	620			53,447
Kingfish			2,538	13,020	42	18,090		33,690				33,690
Mackerel, Horse				20,311		11,688	705	32,704				32,704
Mackerel, Pacific				18,172	2,600	105,629	30,065	156,472				156,472
Mullet							37	37				37
Perch					112	143	141	396				396
Pompano, California						2		2				2
Rock Bass					2,198	21,625	5,066	28,889		425	144	29,458
Rockfish	34,823		38,801	134,143	20,751	21,205	9,282	259,005	700		2,571	262,279
Sablefish	44,349		3,228	8,348		2,715		58,640				58,640
Salmon	242,036	68,408	126,074	268,798				705,466	60			705,466
Sand Dab	19,880		42,362	3,332		411		65,085	130			66,115
Sardine	700		6,200	114,855	490	10,333	490	133,068				133,068
Sculpin					104	13,396	397	13,897				13,897
Sea-bass, Black					3,708	3,067	710	7,584		3,786	510	11,880
Sea-bass, Short-fin							82	82				82
Sea-bass, White					23,784	32,847	12,998	69,629		100	2,553	72,282
Shark	255	5,286	87,800	6,542	422,348	97,174	63,473	682,968			142	683,110
Sheepshead					1,385	879		2,264				2,264
Skate	1,120		4,803	227	1,540	901		8,594				8,594
Smelt	5,405		7,020	11,408	1,712	5,128	2,165	32,838				32,838

Sole	229,305		368,528	18,029	17,217	2,433	90	636,502	29,140			665,642
Split-tail		30						30				30
Swordfish, Broadbill					432	28,001	9,167	37,600				37,600
Tomcod			18					18				18
Tuna, Bluefin					8,152	4,177,469	536,301	4,721,922			185,597	4,907,519
Tuna, Bonito					77	10,454	32,621	43,152			252	43,404
Tuna, Skipjack										1,793,213	1,227,468	3,020,681
Tuna, Yellowfin										3,859,158	6,875,821	10,734,979
Turbot			2,279					2,279				2,279
Whitebait	6,756		4,251	1,483				12,493				12,493
Whitefish, Ocean					231	198		429			193	622
Yellowtail					86	8,016	31,715	39,817		116,033	174,245	330,095
Miscellaneous fish	9,295		5,033	230	3,862	11,487	45	29,952	600			30,552
Crustacean:												
Crab	147,711		347,288	1,302				496,334	480			496,814
Crab, Rock						398		398				398
Shrimp			137,138					137,138				137,138
Mollusk:												
Abalone				83,100	104,450			187,550				187,550
Clam, Cockle			40			1,400		1,440				1,440
Clam, Gaper			320					320				320
Clam, Pismo					15,341			15,341				15,341
Clam, Razor	50							50				50
Clam, Soft-shell			3,870					3,870				3,870
Clam, Washington			128					128				128
Octopus			936	4,971				5,907				5,907
Oyster, Eastern			5,368					5,368				5,368
Oyster, Japanese			40,054					40,054				40,054
Oyster, Native			3,702					3,702				3,702
Squid				79,620				79,620				79,620
Total pounds	854,470	76,211	1,303,288	794,401	668,979	4,931,697	787,824	9,416,870	31,730	5,778,135	8,472,487	23,694,228

* See footnote to table for April.

SHIPMENTS OF FRESH FISH FROM OTHER STATES AND FOREIGN COUNTRIES

April, 1940

	Oregon and Washington	Gulf of California	Japan
For canneries:			
Tuna, Albacore	12,000		
Tuna, Skipjack			102,587
For fresh fish markets:*			
Cabrilla		85	
Corbina, Mexican		8,320	
Sea-bass, Totuava		31,612	
Miscellaneous Fish		720	
Total pounds	12,000	40,737	102,587

May, 1940

	Oregon and Washington	Gulf of California	Japan
For fresh fish markets:*			
Cabrilla		4,524	
Corbina, Mexican		3,431	
Sea-bass, Totuava		101,741	
Miscellaneous Fish		1,705	
Total pounds		111,401	

June, 1940

	Oregon and Washington	Gulf of California	Japan
For canneries:			
Tuna, Skipjack			100,190
For fresh fish markets:*			
Cabrilla		7,255	
Corbina, Mexican		252	
Sea-bass, Black		600	
Sea-bass, Totuava		76,017	
Miscellaneous Fish		145	
Total pounds		84,299	100,190

* This record includes only that fish which is voluntarily reported to the Division of Fish and Game and does not represent all shipments.

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